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THE BASIC DYNAMIC MODEL OF THE AIRLIFT
SERVICE INDUSTRIAL FUND OF THE MILITARY
AIRLIFT COMMAND

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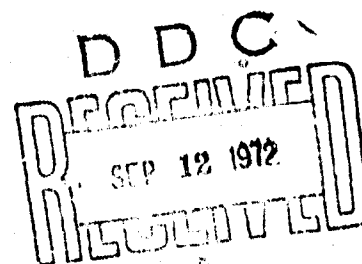
THE BASIC DYNAMIC MODEL OF THE AIRLIFT SERVICE INDUSTRIAL FUND OF THE MILITARY AIRLIFT COMMAND

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16. Abstract This report describes in detail the model developed of the Military Airlift Command Industrial Fund. This report begins with a description of the Industrial Fund, its objectives and its constraints. The model variables are then identified and their interrelationships described. The modeling technique utilized is "Industrial Dynamics" which provided a method for simulating the time varying behavior of the real system. The completed model is provided in the Appendix.					
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THE BASIC DYNAMIC MODEL

The purpose of this report is to describe what will be referred to as the basic dynamic model of the Airlift Service Industrial Fund (ASIF). This basic model is the result of our Analysis of the Industrial Fund System and utilizes the "Industrial Dynamics" approach to model the dynamic characteristics of the Industrial Fund. (For detailed explanation of the Industrial Dynamics approach to system analysis see J. W. Forrester's book, Industrial Dynamics, M.I.T. Press, Cambridge, Massachusetts, 1961.) This model will be used to simulate the dynamic characteristics of the real system and to test proposed system modifications. The end result will hopefully be better understanding of the dynamics of the real system and increased confidence in the probable benefit of proposed system modifications.

This model is the result of many hours of discussion between the analyst and the managers of the Industrial Fund and is a representation of the Industrial Fund system at the present time.

Background

This project was initiated during the summer of 1967 when the analyst was working with the Military Airlift Command's Operations Analysis office at Scott Air Force Base, Illinois. During this period the analyst became acquainted with ASIF and proposed its analysis using the "Industrial Dynamics" approach. At that time it was thought that the model could be developed fairly quickly and then be used to analyze the dynamics of the Industrial Fund.

While the project proposal was accepted and the development of the model began, the resulting basic model has been achieved slowly. Interim reports were presented in the spring of 1968 and in April of 1969.

The modeling technique utilized has been one developed by J. W. Forrester of M.I.T. called "Industrial Dynamics". The industrial dynamics technique utilizes a compiler program called "Dynamo". Dynamo enables the researcher, after describing his model in mnemonic language and quantifying the many variables, to simulate the system dynamics on a computer. In April of 1969, the "Dynamo" Compiler was just being completed for the IBM 360/67 equipment used by the Iowa State University Computation Center. The programming of the "Dynamo" Compiler for the current IBM equipment had taken longer than anticipated and the model building activities had been delayed.

Method of Analysis

The method of analysis being utilized in studying the industrial fund proceeds according to the following five steps.

First: Identify the system variables and their interrelationship.

The analyst has spent many hours in discussion with ASIF personnel to identify the significant variables within the ASIF system and their interrelationships as a part of a dynamic system. This phase of the procedure is continually in operation as further steps are completed and discussed by the ASIF managers and the analyst.

Second: Develop a basic model of the ASIF System.

This basic model is described in this report. The report identifies the variables selected and quantifies the relationships between the different variables. The system is assumed to be a closed system operating continuously with linear relationships between the variables over very short time intervals.

Third: Simulate the ASIF system on a computer using the basic model.

This step is in progress and the analysis and conclusions will be the subject of a later report.

Fourth: Test system changes or modifications via simulation on a revised basic model.

Proposed system changes or modifications will be studied by revising the basic model to incorporate the proposed modification. This step will be incorporated in the report referenced in step three.

Fifth: Propose system changes.

Based on the conclusions reached in steps three and four, proposed system changes may be recommended.

It must be clearly understood that the purpose of this model is to represent the dynamic aspects of the real system and enable the analyst to manipulate and study the model, thereby gaining valuable insight into the real system. The model, for obvious reasons, must be, and is, a simplification of the real system. However, it must identify the significant variables with their interrelationships so that the model dynamics realistically represents the real system.

The simpler the model, while still representative of the real system, the better from a model building and analysis standpoint. The model may later be made more sophisticated as deemed necessary for analysis purposes as outlined in steps three and four.

The Industrial Fund

The Airlift Industrial Fund (ASIF) is a MAC management tool established to:

- a) provide an effective means for controlling the costs of airlift capability,
- b) provide for the rational recovery of airlift costs from airlift users, and
- c) motivate users toward prudent use of airlift capability supplied by MAC.

A number of problems are encountered by the ASIF when attempting to develop a tariff structure which fulfills the following objectives:

- a) Allow for the strategic disposition of the Military Force;

- b) Provide equitable rates to users;
- c. Recognize utilization of airframe capabilities;
- d) Provide for a revenue-expense breakeven at specified time intervals on both PAX and Cargo shipments;
- e) Charge premium rates for premium service;
- f) Maintain tariff stability; and
- g) Motivate efficient user usage.

The Basic ASIF Model

In developing the basic ASIF model a general description was obtained from ASIF personnel regarding the operation of the Fund. System boundaries and system variables were identified and a description was obtained of the significant cause-effect relationships. The model was developed from a general description of the system and the system variables and became more sophisticated as different variable interrelationships were deemed significant and included in the model.

The ASIF is responsible for the determination of airlift tariffs. These tariffs are established with the goal of recovering airlift costs from airlift users. The users are billed for the airlift service providing revenue (or income) to the Industrial Fund. The tariff is influenced by forecasted airlift costs, and forecasted airlift demand. Airlift costs are based on aircraft availability, utilization, and maintenance, as well as administrative and operational support functions.

As airlift services are provided, revenue is generated as well as expenses. If total revenue exceeds or lags actual expenses, the tariff may need revision to enable the ASIF to break even at the end of a specified time period.

The model which has been developed, and is described in this report, represents the forecasting system by which demand and costs are estimated and incorporated with airlift capacity to yield a forecasted tariff rate; the determination of airlift capacity and its allocation to customer demand; the billing activity initiated by the movement of material or passengers and influenced by the tariff; the accounting and payment of expenses generated by ASIF activities; and the determination of total revenue and total costs and any out of balance condition resulting.

In developing the model, four classifications of customer demand were recognized as each influenced the tariff calculations in a particular way. Customer demand is classified as Cargo, PAX (passengers), SAAM (special assignment airlift missions), or Exercises. Cargo and PAX may be moved by contract with commercial airlines. While SAAM's may utilize commercial aircraft in the real system, its use is limited and not represented in the model at this time.

The users of MAC move material and passengers over specified routes generating Ton-miles or PAX-miles of usage. The modeling of this aspect of the real system has required some simplifying assumptions. For simplicity, we

have assumed that customer demand is in Ton-miles/week or PAX-miles/week. This demand, however, needs to be identified as outgoing (from CONUS) or incoming (to CONUS) for airlift capability required has been assumed to be twice the larger demand. For example, when outgoing is larger, the planes will return empty or partially loaded.

In summary, the model represents the following activities:

- a) The customer's demand and movement of Cargo, PAX, SAAM, and Exercise.
- b) The Industrial Fund manifesting and billing for services provided.
- c) The determination of military airlift capability and commercial requirements and their allocation to customer demand.
- d) The generation of expenses within the ASIF.
- e) The cash flow due to payment of expenses and receipt of revenue.
- f) The forecasting of customer demand and ASIF expenses to generate a new tariff rate.
- g) The determination of revenue-expense differences leading to a decision to change the tariff rate.

In the following discussion each figure represents a segment of the basic model of the total ASIF system. Each variable in the system is identified and the variable equation given. The identification of each variable is by mnemonic language. A variable may be identified as part of the Cargo, PAX, SAAM, or Exercise system by the number 1, 2, 3, or 4, respectively, in the variable name.

Each variable is also assigned a number which identifies the variable and the figure which shows that variable's interrelationships with other variables. Thus, variable 6.09 identifies variable 09 of Figure 6 and variable 11.22 identifies variable 22 of Figure 11. This will assist in the identification and location of the different variables when necessary during study and analysis.

Following the industrial dynamics terminology, three points in time, J, K, and L, are identified. "J" represents a point in time in the immediate past, "K" is the present time and "L" a point in time in the immediate future. Each point in time is separated by the time interval DT . Variables, called rate variables, which identify the rate of change over the time interval DT and between J and K are identified by "JK" in the variable name and the rate of change between K and L is noted by a "KL" in the variable name. A "K" or "J" in the variable name identify the magnitude of a level or auxiliary variable at that point in time.

In the figures, a solid line will represent the flow of material, paper work (manifests, bill, etc.) or cash, while a dotted line indicates the influence of information. A dotted line into a variable would indicate that the value of that variable would be influenced by information from the variable or variables originating the dotted line. All flows are in the direction of the arrow. For more detail on the flow diagrams see Chapter 8 of 'Industrial Dynamics' by J. W. Forrester.

Figure 1

The Military Airlift Command moves cargo and passenger per customer demand and in Figure 1 the movement of cargo per customer demand has been modeled. Customer demand is assumed to be an exogenous variable and influenced by factors outside the ASIF. This may be revised later to show a feedback effect on customer demand by ASIF tariffs if it is deemed significant.

1.01 $D1G$ Customer Demand-Cargo-Outgoing (Ton-Miles/week)

1.02 $D1C$ Customer Demand-Cargo-Incoming (Ton-Miles/week)

It is assumed that material moved to MAC terminals during an interval of time is equal to customer demand at the beginning of that time interval. Rate equations 1.05 and 1.06 are written to represent the movement of material to the terminals.

1.05 $IS1G.KL = D1G.K$

1.06 $IS1C.KL = D1C.K$

$IS1G$ = Incoming shipment rate (to terminals)-Cargo-Outgoing (Ton-Miles/week)

$IS1C$ = Incoming shipment rate (to terminals)-Cargo-Incoming (Ton-Miles/week)

Terminal inventory at a point in time is equal to the terminal inventory at the last time period plus incoming shipments and less outgoing shipments over that time period. Level equations 1.07 and 1.08 are written to represent these variables.

1.07 $IN1G.K = IN1G.J + (DT)(IS1G.JK - S1G.JK)$

1.08 $IN1C.K = IN1C.J + (DT)(IS1C.JK - S1C.JK)$

$IN1G$ = Terminal Inventory-Cargo-Outgoing (Ton-Miles)

$IN1C$ = Terminal Inventory-Cargo-Incoming (Ton-Miles)

Shipments from the terminal are assumed to be determined by the terminal inventory ($IN1G$ and $IN1C$) and the policy to move any material received within a specified time limit. The basic model is based on the policy to ship material from the terminal within two days after receipt of the material. Because of the nature of the modeling technique and the need to later allocate military and commercial capability to cargo movement, we have written the following equations.

We identify two variables as follows:

1.09 $S1GT.K = IN1G.K(1/D17)$

1.10 $S1CT.K = IN1C.K(1/D17)$

$S1GT$ = Shipping Rate-Cargo-Outgoing-Tested (Ton-Miles/week)

$S1CT$ = Shipping Rate-Cargo-Incoming-Tested (Ton-Miles/week)

1.61 $D17 = \text{Delay in shipping (Weeks)}$

1.62 $D18 = \text{Delay in shipping (Weeks)}$

The shipping rate over time period KL is then represented as follows:

1.03 $SlG.KL = SlGT.K$

1.04 $SlC.KL = SlCT.K$

$SlG = \text{Shipping Rate-Cargo-Outgoing (Ton-Miles/week)}$

$SlC = \text{Shipping Rate-Cargo-Incoming (Ton-Miles/week)}$

Military capability is allocated to cargo movement and commercial requirements are utilized to cover any deficits in capability. Variables 1.11 through 1.16 in Figure 1 model this aspect of the system. The capacity of the airframe is not utilized 100%, so the material moved ($SlGT$ and $SlCT$) is divided by the utilization of the airframe to give the total airframe capability required.

1.65 $U1G = \text{ACL Utilization-Cargo-Outgoing (\%)}$

1.66 $U1C = \text{ACL Utilization-Cargo-Incoming (\%)}$

1.11 $C1G.K = (SlGT.K) / U1G$

1.12 $C1C.K = (SlCT.K) / U1C$

$C1G = \text{Required Capability-Cargo-Outgoing (Ton-Miles/week)}$

$C1C = \text{Required Capability-Cargo-Incoming (Ton-Miles/week)}$

It is assumed that airframes moving material outgoing will return with incoming material. Therefore, the total capability allocated to cargo movement will be twice the capability required to move either outgoing or incoming shipments, whichever is the larger.

This is determined in the model by variable 1.14 and its equation is written as follows.

1.14 $MX1.K = \text{MAX } (C1G.K, C1C.K)$

$MX1 = \text{Maximum Demand (Ton-Miles/week)}$

Then the capability required is

1.13 $TC1.K = 2 * MX1.K$

$TC1.K = \text{Total Required Capability-Cargo-(Ton-Miles/week)}$

The available military capability is applied to this requirement and the balance is covered by a commercial buy ($CB1$).

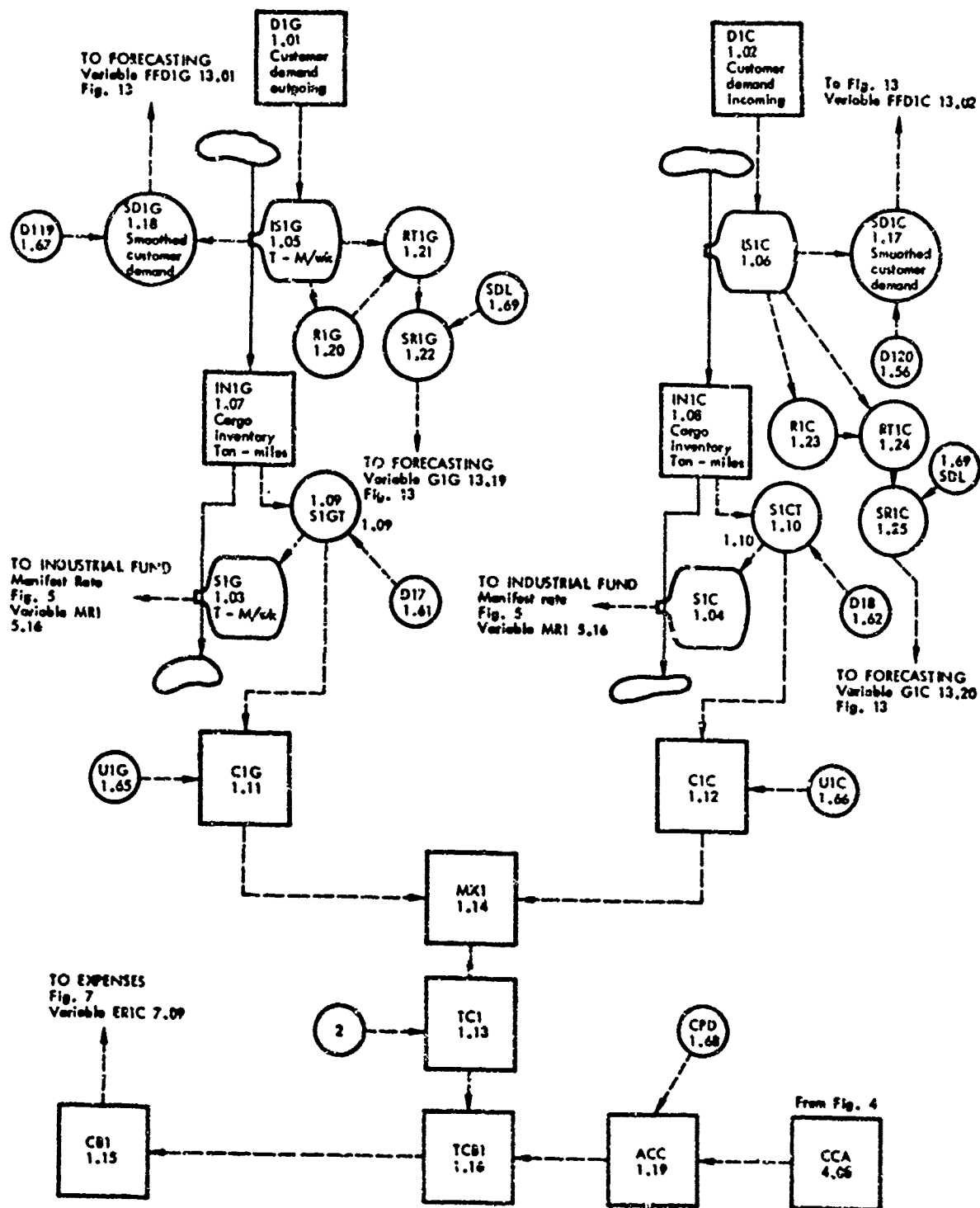


Figure 1. Model of Cargo Movement.

The military capacity available is determined in Figure 4 and results in variable 4.08 identified as the Cargo Capability Available. Because of the need for positioning and deposition of aircraft, the quantity actually available for use is something less than this. This is accomplished by a multiplier (CPD) of less than one.

$$1.19 \quad ACC.K = CCA.K * CPD$$

$$1.68 \quad CPD = 0.907$$

ACC = Actual Cargo Capacity Available-(Ton-Miles/week)

CPD = Cargo Positioning-Depositioning Multiplier

The commercial buy can never be less than zero. If the military capacity is more than sufficient, it is used to move the customer's demand. That is, the total military capability available is used regardless of the quantity demanded and commercial requirements are purchased only if needed.

This is represented in the model by a clip function as follows:

$$1.16 \quad TCB1.K = TC1.K - ACC.K$$

TCB1 = Tested Commercial Buy (Ton-Miles/week)

$$1.15 \quad CB1.KL = CLIP (TCB1.K, 0, TCB1.K, 0)$$

CB1 = Commercial Buy (Ton-Miles/week)

This is interpreted as follows. If TCB1 is equal to or greater than 0 then CB1 is set equal to TCB1. However, if TCB1 is less than 0, which means no commercial buy is required, CB1 is set equal to 0.

In another segment of the model we need to determine the forecasted customer requirements. We have hypothesized that this forecast is influenced by the customer's previous demand and the rate of change in this demand. These variables and their modeling will need to be described.

It is assumed that the forecasted customer demand is determined by the average demand over a past period of time. We have utilized exponential averaging in our model which means the most recent occurrence will be given greater weight in determining the average customer demand. (See pg. 406 of the Forrester text) We have also assumed that this averaging occurs over a six-month time period. In other words, the forecasted customer demand is a function of the actual demand over the past six months.

The average customer demand is determined by a smoothing equation as follows:

$$1.18 \quad SD1G.K = SD1G.J + (DT/D119)(IS1G.JK - SD1G.J)$$

$$1.17 \quad SD1C.K = SD1C.J + (DT/D120)(IS1C.JK - SD1C.J)$$

1.67 $DL19 = \text{Delay in smoothing (weeks)}$

1.56 $DL20 = \text{Delay in smoothing (weeks)}$

$SD1G = \text{Smoothed Customer Demand-Cargo-Outgoing (Ton-Miles/week)}$

$SD1C = \text{Smoothed Customer Demand-Cargo-Incoming (Ton-Miles/week)}$

The rate of change in demand is also assumed to be an average of the rate of change over a period of time the immediate past. Again it has been assumed that the most immediate past rate of change will have the greatest influence.

If we let $R1G$ equal the customer's demand over the previous time period in Ton-Miles/week, then

1.20 $R1G.KL = IS1G.JK$

The rate of change in demand $RT1G$ during the previous time period can then be written as follows:

1.21 $RT1G.K = (1/DT)(IS1G.JK - R1G.JK)$

In this equation $R1G.JK$ is equal to $IS1G$ in the time period $JK - 1$.

The average rate of change over the past SDL weeks is written as a smoothing equation (Exponential smoothing utilized).

1.22 $SR1G.K = SR1G.J + (DT/SDL)(RT1G.J - SR1G.J)$

$SR1G = \text{Smoothed rate of growth over the past } SDL \text{ weeks (Ton-Miles/week/week)}$

1.69 $SDL = \text{Smoothing time period (weeks)}$

Initially we have assumed the smoothing time period (SDL) over which the rate of growth is determined is 20 weeks.

The above equations represent the modeling of the rate of change in customer demand for moving outgoing Cargo. In the same manner we needed the rate of change in demand for incoming Cargo.

1.23 $R1C.KL = IS1C.JK$

1.24 $RT1C.K = (1/DT)(IS1C.JK - R1C.JK)$

1.25 $SR1C.K = SR1C.J + (DT/SDL)(RT1C.J - SR1C.J)$

$R1C = \text{Customer Demand-Past time period - (Ton-Miles/week)}$

$RT1C = \text{Rate of Growth over previous time period (Ton-Miles/week/week)}$

$SR1C = \text{Smoothed Rate of Growth over the past } SDL \text{ weeks (Ton-Miles/week/week)}$

The above equations complete the modeling of customer demand for and the movement of cargo out of and into CONUS with the resulting allocation of military capability to this demand and the determination of needed additional commercial requirements.

A list of all variables identified in Figure 1 and their corresponding initial conditions and parameters is given in Appendix I.

Figure 2

The movement of passengers (PAX) by Military Airlift Command is modeled in Figure 2. The customer, in the same manner as with Cargo, moves PAX out of and into CONUS. The modeling of this activity is practically identical to the modeling of Cargo movement.

The equations which follow represent the customer's demand for movement of PAX (outgoing and incoming), the movement of PAX to terminals and their shipment, with the appropriate allocation of commercial and military capability to this demand. The variables are therefore identified in the same manner as Cargo variables except the number "2" is used to represent PAX movement in place of the "1" representing Cargo movement.

2.01 D2C Customer Demand-PAX-Outgoing (PAX-Miles/week)

2.02 D2C Customer Demand-PAX-Incoming (PAX-Miles/week)

2.05 IS2G.KL = D2C.K

2.06 IS2C.KL = D2C.K

IS2G = Incoming PAX requirements-Outgoing (PAX-Miles/week)

IS2C = Incoming PAX requirements-Incoming (PAX-Miles/week)

2.07 IN2G.K = IN2G.J + DT(IS2G.JK - S2G.JK)

2.08 IN2C.K = IN2C.J + DT(IS2C.JK - S2G.JK)

IN2G = Terminal Inventory-PAX-Outgoing (PAX-Miles)

IN2C = Terminal Inventory-PAX-Incoming (PAX-Miles)

2.12 S2GT.K = IN2G.K/D27

2.14 S2CT.K = IN2C.K/D28

S2GT = Shipping Rate - PAX-Outgoing-Tested (PAX-Miles/week)

S2CT = Shipping Rate - PAX-Incoming-Tested (PAX-Miles/week)

2.60 D27 = Delay in shipping (weeks)

2.61 D28 = Delay in shipping (weeks)

2.13 S2G.KL = S2GT.K

2.15 S2C.KL = S2CT.K

S2G = Shipments-PAX-Outgoing (PAX-Miles/week)

S2C = Shipments-PAX-Incoming (PAX-Miles/week)

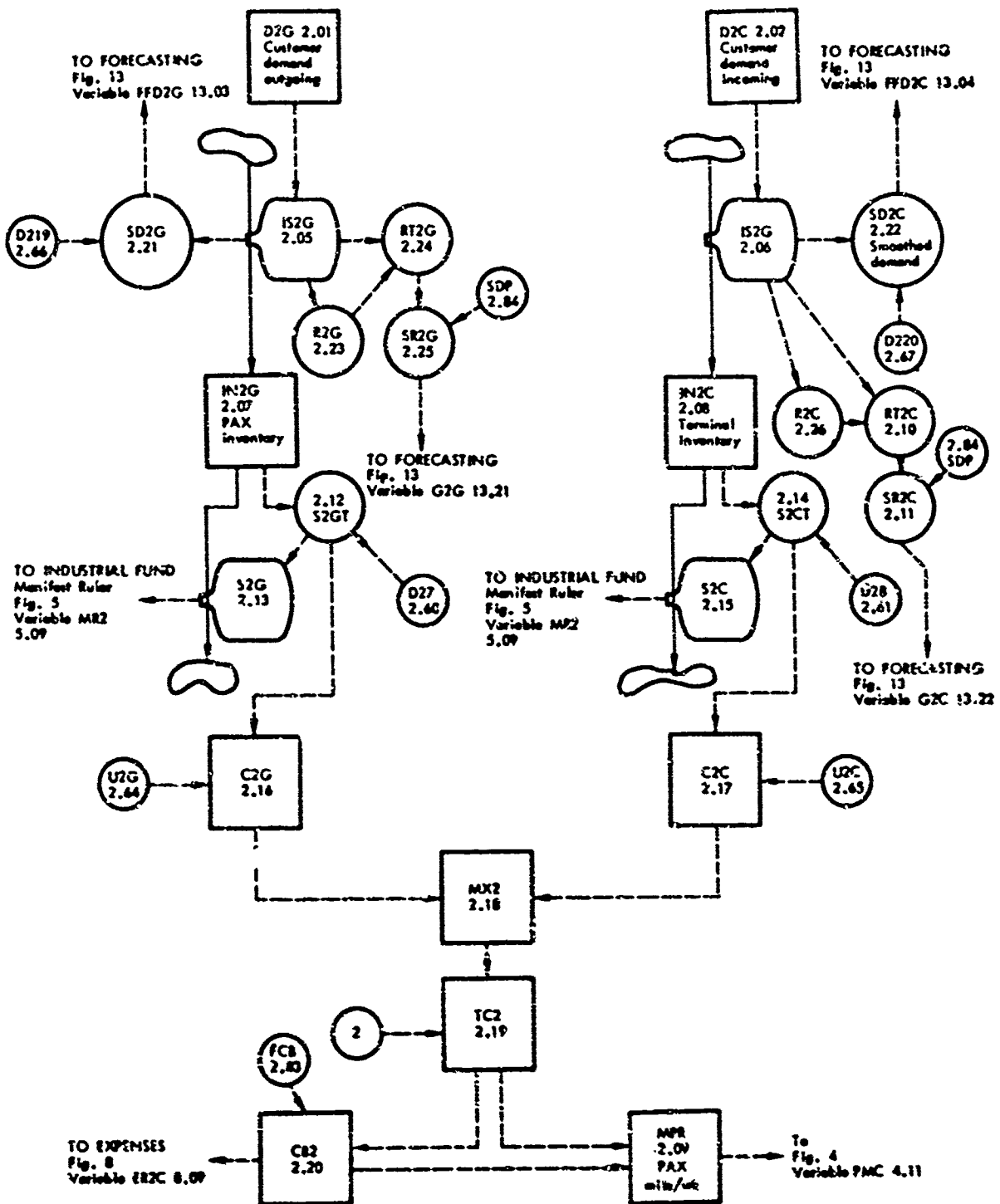


Figure 2. Model of PAX Movement.

$$2.64 \quad U2G = \text{ACL utilization-PAX-Outgoing (\%)}$$

$$2.65 \quad U2C = \text{ACL utilization-PAX-Incoming (\%)}$$

$$2.16 \quad C2G.K = S2GT.K/U2G$$

$$2.17 \quad C2C.K = S2CT.K/U2C$$

$$2.18 \quad MX2.K = \text{MAX } (C2G.K, C2C.K)$$

$$2.19 \quad TC2.K = 2 * MX2.K$$

$C2G$ = Required capability-PAX-Outgoing (PAX-Miles/week)

$C2C$ = Required capability-PAX-Incoming (PAX-Miles/week)

$MX2$ = Maximum demand (PAX-Miles/week)

$TC2$ = Total capability required - PAX (PAX-Miles/week)

In the case of PAX movement, it is assumed that commercial capability is bought to cover the majority of the demand with military capability being utilized for the balance.

The commercial buy is then determined by the following equation:

$$2.20 \quad CB2.K = TC2.K \div FCB$$

$CB2$ = Commercial Buy for PAX (PAX-Miles/week)

$$2.81 \quad FCB = \text{Portion of total requirement covered by Commercial.}$$

FCB will be between zero and one and is assumed in the basic model to be 0.92. This then means 92% of the total PAX requirements are moved by commercial aircraft under contract with MAC.

Military requirements then are

$$2.09 \quad MPR.K = TC2.K - CB2.K$$

MPR = Military Capability required (PAX-Miles/week)

The average demand for PAX movement and the rate of change in PAX movement is modeled by equations similar to those described for Cargo movement. They are shown below.

$$2.21 \quad SD2G.K = SD2G.J + (DT/D219)(IS2G.JK - SD2G.J)$$

$$2.22 \quad SD2C.K = SD2C.J + (DT/D220)(IS2C.JK - SD2C.J)$$

$$2.66 \quad D219 = \text{Delay in smoothing (weeks)}$$

$$2.67 \quad D220 = \text{Delay in smoothing (weeks)}$$

SD2C = Smoothed customer PAX requirements-Outgoing (PAX-Miles/week)

SD2C = Smoothed customer PAX requirements-Incoming (PAX-Miles/week)

$$2.23 \quad R2G.KL = IS2G.JK$$

$$2.26 \quad R2C.KL = IS2C.JK$$

$$2.24 \quad RT2G.K = (1/DT)(IS2G.JK - R2G.JK)$$

$$2.10 \quad RT2C.K = (1/DT)(IS2C.JK - R2C.JK)$$

$$2.25 \quad SR2G.K = SR2G.J + (DT/SDP)(RT2G.J - SR2G.J)$$

$$2.11 \quad SR2C.K = SR2C.J + (DT/SDP)(RT2C.J - SR2C.J)$$

$$2.84 \quad SDP = \text{Smoothing Delay (weeks)}$$

R2G = Customer demand-Past time period-Outgoing (PAX-Miles/week)

R2C = Customer demand-Past time period-Incoming (PAX-Miles/week)

RT2G = Rate of Change-over previous time period-Outgoing (PAX-Miles/week/week)

RT2C = Rate of Change-over previous time period-Incoming (PAX-Miles/week/week)

SR2G = Smoothed Rate of Change over past SDP weeks-Outgoing (PAX-Miles/week/week)

SR2C = Smoothed Rate of Change over past SDP weeks-Incoming (PAX-Miles/week/week)

The above equations complete the modeling of customer demand for and the movement of PAX out of and into CONUS, with the commercial buy requirements generated by this movement and the military capability required for the balance.

A list of all variables identified in Figure 2 and their corresponding initial conditions and parameters is given in Appendix II.

Figure 3

Customer demand for and the movement of designated SAAM and Exercise requirements are modeled in Figure 3. This segment of the total model is similar to the Cargo and PAX segments of Figures 1 and 2. The equations are also similar and will utilize the numbers "3" and "4" to represent SAAM's and Exercises, respectively.

$$3.01 \quad D3S = \text{Customer demand for SAAM (Ton-Miles/week)}$$

$$3.02 \quad D4E = \text{Customer demand for Exercises (Ton-Miles/week)}$$

As before, the movement rate to MAC terminals is assumed to equate the customer demand, which is the exogenous variable.

Therefore,

$$3.05 \quad IS3.KL = D3S.K$$

$$3.06 \quad IS4.KL = D4E.K$$

$IS3$ = Incoming SAAM requirements (Ton-Miles/week)

$IS4$ = Incoming Exercise requirements (Ton-Miles/week)

The movement of SAAM and Exercise requirements is represented, in this case, by third order delay functions. This provides for more realistic simulation of the planning and lead time allowed in SAAM and Exercise movement.

$$3.07 \quad IN3.K = IN3.J + DT(IS3.JK - S3S.JK)$$

$$3.09 \quad S3S.KL = Delay3(IS3.JK, D34)$$

$$3.62 \quad D34 = Delay \text{ in SAAM movement (weeks)}$$

$S3S$ = Shipment of SAAM Requirements (Ton-Miles/week)

$IN3$ = Inventory of Planned SAAM movement (Ton-Miles/week)

$$3.08 \quad IN4.K = IN4.J + DT(IS4.JK - S4E.JK)$$

$$3.10 \quad S4E.KL = Delay3(IS4.JK, D316)$$

$$3.63 \quad D316 = Delay \text{ in Exercise movement (weeks)}$$

$IN4$ = Inventory of Planned Exercise Movement (Ton-Miles)

$S4E$ = Shipment of Exercise Requirements (Ton-Miles/week)

Both SAAM and Exercise requirements are smoothed for forecasting purposes in the model. The rate of change in the demand for SAAM and Exercise requirements is also determined.

$$3.64 \quad D312 = Delay \text{ in smoothing SAAM (weeks)}$$

$$3.65 \quad D38 = Delay \text{ in smoothing Exercises (weeks)}$$

$$3.11 \quad SD3.K = SD3.J + (DT/D312)(IS3.JK - SD3.J)$$

$$3.12 \quad SD4.K = SD4.J + (DT/D38)(IS4.JK - SD4.J)$$

$SD3$ = Smoothed demand for SAAM's (Ton-Miles/week)

$SD4$ = Smoothed demand for Exercises (Ton-Miles/week)

$$3.15 \quad R3.KL = IS3.JK$$

$$3.16 \quad R4.KL = IS4.JK$$

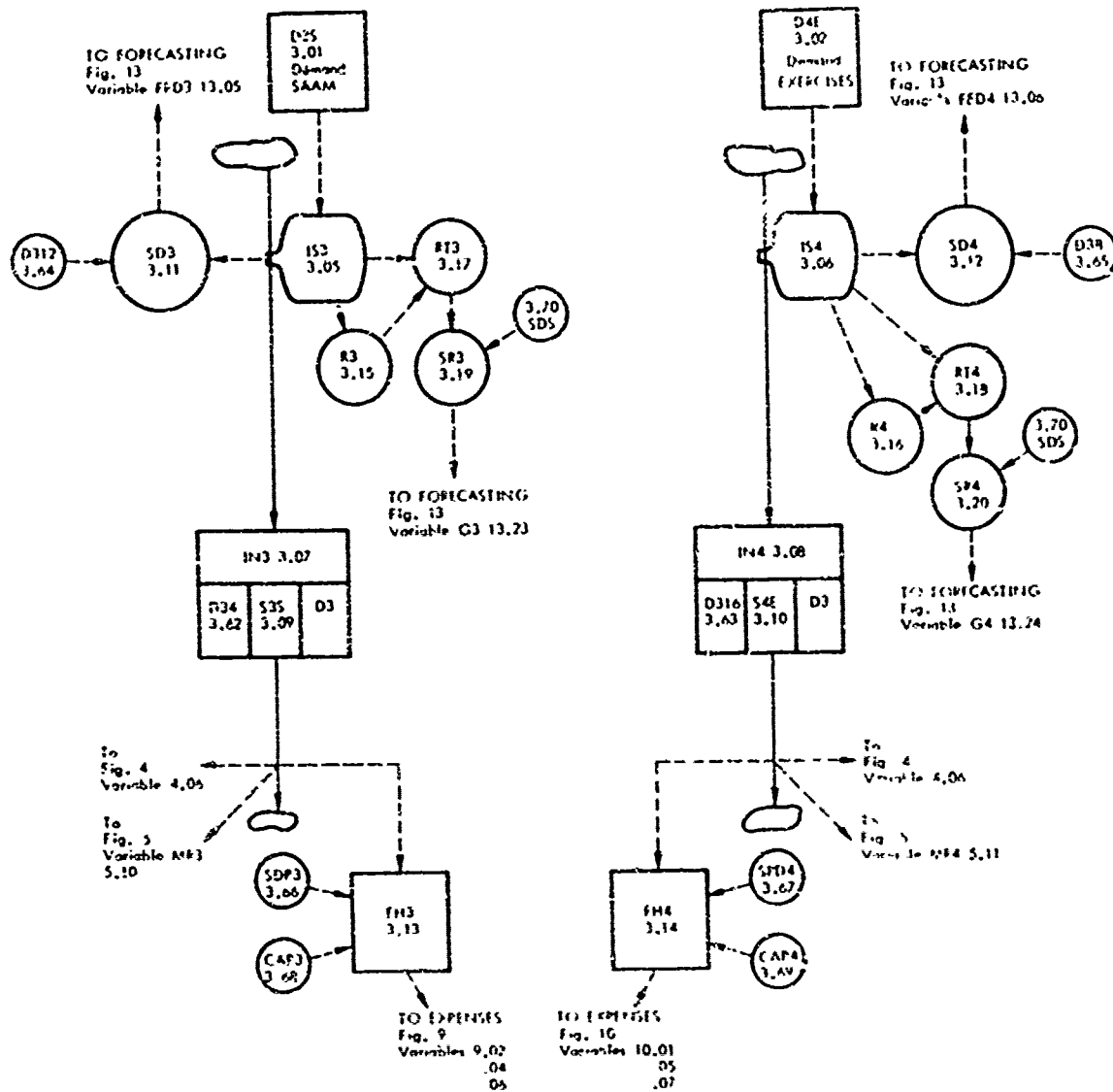


Figure 3. Model of SAAM and Exercise Movement

R3 = SAAM movement over previous time period (Ton-Miles/week)

R4 = Exercise movement over previous time period (Ton-Miles/week)

$$3.17 \quad RT3.K = (1/DT)(IS3.JK - R3.JK)$$

$$3.18 \quad RT4.K = (1/DT)(IS4.JK - R4.JK)$$

RT3 = Growth Rate in SAAM Demand over past DT (Ton-Miles/week/week)

RT4 = Growth Rate in Exercise Demand over past DT (Ton-Miles/week/week)

$$3.19 \quad SR3.K = SR3.J + (DT/SDS)(RT3.J - SR3.J)$$

$$3.20 \quad SR4.K = SR4.J + (DT/SDS)(RT4.J - SR4.J)$$

SR3 = Smoothed Rate of Growth over past SDS weeks (Ton-Miles/week/week)

SR4 = Smoothed Rate of Growth over past SDS weeks (Ton-Miles/week/week)

$$3.70 \quad SDS = \text{Smoothing Delay (weeks)}$$

It is assumed that the movement of SAAM's and Exercise requirements is accomplished by military capability only. The military capability required for SAAM and Exercise movement is determined and allocated first with the remaining military capability utilized for Cargo and PAX movement. The modeling of this series of decisions is shown in Figure 4.

The SAAM and Exercise flying hours utilized in later expense calculations is modeled as a segment of Figure 3. The flying hours generated is determined by dividing the ton-miles flown by the speed of the aircraft and its capacity. Both SAAM and Exercises are billed on a total capacity basis.

$$\text{Flying hours} = \frac{\text{Material Moved (Ton-Miles/Week)}}{\text{Speed Capacity} \begin{matrix} \text{(Miles)} \\ \text{(Hour)} \end{matrix} \begin{matrix} \text{(Tons)} \end{matrix}}$$

The equations are therefore

$$3.66 \quad SPD3 = \text{Speed of Aircraft (MPH)}$$

$$3.67 \quad SPD4 = \text{Speed of Aircraft (MPH)}$$

$$3.68 \quad CAP3 = \text{Capacity of Aircraft (Tons)}$$

$$3.69 \quad CAP4 = \text{Capacity of Aircraft (Tons)}$$

$$3.13 \quad FH3.K = S3S.JK / ((SPD3)(CAP3))$$

$$3.14 \quad FH4.K = S4E.JK / ((SPD4)(CAP4))$$

FH3 = Flying hours rate for SAAM (Flying-hours/week)

FH4 = Flying hours rate for Exercise (Flying-hours/week)

This completes the modeling of customer demand for MAC services which are billed under the Industrial Fund. Figures 1, 2, and 3 represent these segments of the total model of the Industrial Fund.

A list of all variables identified in Figure 3 and their corresponding initial conditions and parameters is given in Appendix III.

Figure 4

We now turn to that segment of the model which represents the determination of total military capability and allocates it to PAX, Cargo, SAAM, and Exercise movement requirements. This is modeled in Figure 4 which also includes the determination of flying hours for PAX and Cargo movement. The flying hour information with that from Figure 3 is used as input in that segment of the model where ASIF expense rates are modeled.

For simplification purposes we assume that MAC flies only the C141. The total flying hours available per week is then calculated as follows:

$$4.01 \quad TFHC.K = TAF.K * UTAF$$

TFHC = Total Flying Hours Capability (Flying-hours/week)

TAF = Total Air Frames Available

UTAF = Utilization of Air Frames (Flying-hours/week)

The total air frames available is an exogenous input and may be constant or varied over time. The equation for TAF is written as follows:

$$4.03 \quad TAF.K = TAFI + AFI.K$$

TAFI = Initial Air Frames Available

AFI = Increased Air Frames put in service

AFI represents a variable which increases or decreases the number of air frames available if so desired by the analyst. Initially, we have provided for a growth of air frames available by the following equation.

$$4.02 \quad AFI.K = RAMP(RMP, 5)$$

RMP = Rate of Growth of Air Frames (Air Frames/week)

The total flying hour capability is now converted to a ton-mile/week capability by multiplying it by speed and capacity factors.

$$4.04 \quad TCAP.K = TFHC.K * SPD * CAP$$

$$\text{Ton-Miles/week} = \frac{\text{Flying hours}}{\text{Week}} * \frac{\text{Miles}}{\text{Hour}} * \text{Tons}$$

TCAP = Total Military Capability Available (Ton-Miles/week)

4.55 SPD = Speed of Aircraft (MPH)

4.56 CAP = Capability of Aircraft (Tons)

The first demand on military capability is for training and testing requirements (TRN).

Training and testing requirements are assumed to be constant unless the total commercial buy drops below a specified amount. When this occurs there is an increase in training and testing requirements until the commercial buy has been increased to the desired minimum level. This represents a system boundary condition for the model. MAC makes a commitment to use a specified minimum amount of commercial aircraft. As this minimum figure is approached, military usage is increased so as to require the need for the minimum contract figure.

Variables ER1C and ER2C represent the expense rate for the commercial buy for Cargo and PAX requirements in dollars/week. This expense rate is smoothed (averaged) over time periods DXC and DXP to yield variables SX1 and SX2. In the initial model the smoothing time period for DXC and DXP is 25 weeks.

The sum of SX1 and SX2 gives a smoothed average weekly commercial cost. This figure is now compared to the minimum average weekly commercial buy allowable (CEG) to determine whether training and testing requirements need to be increased.

The following equations represent this decision series.

$$4.15 \quad SX1.K = SX1.J + (DT/DXC)(ER1C.JK - SX1.J)$$

$$4.16 \quad SX2.K = SX2.J + (DT/DXP)(ER2C.JK - SX2.J)$$

SX1 = Smoothed commercial expense rate-Cargo (dollars/week)

SX2 = Smoothed commercial expense rate-PAX (dollars/week)

$$4.71 \quad DXC = \text{Delay in smoothing (weeks)}$$

$$4.72 \quad DXP = \text{Delay in smoothing (weeks)}$$

$$4.17 \quad SXX.K = SX1.K + SX2.K$$

SXX = Smoothed Total Commercial Expense Rate (\$/week)

$$4.18 \quad RTO.K = SXX.K/CEG$$

RTO = Ratio Actual Expense to Minimum Allowed

$$4.69 \quad CEG = \text{Minimum Allowable Commercial Buy Rate ($/week)}$$

It is assumed that if RTO is equal to or greater than 1 no increase is necessary for testing and training requirements (TRN). If RTO is less than 1, TRN will be increased by a multiplier MLT. For the purposes of the basic model

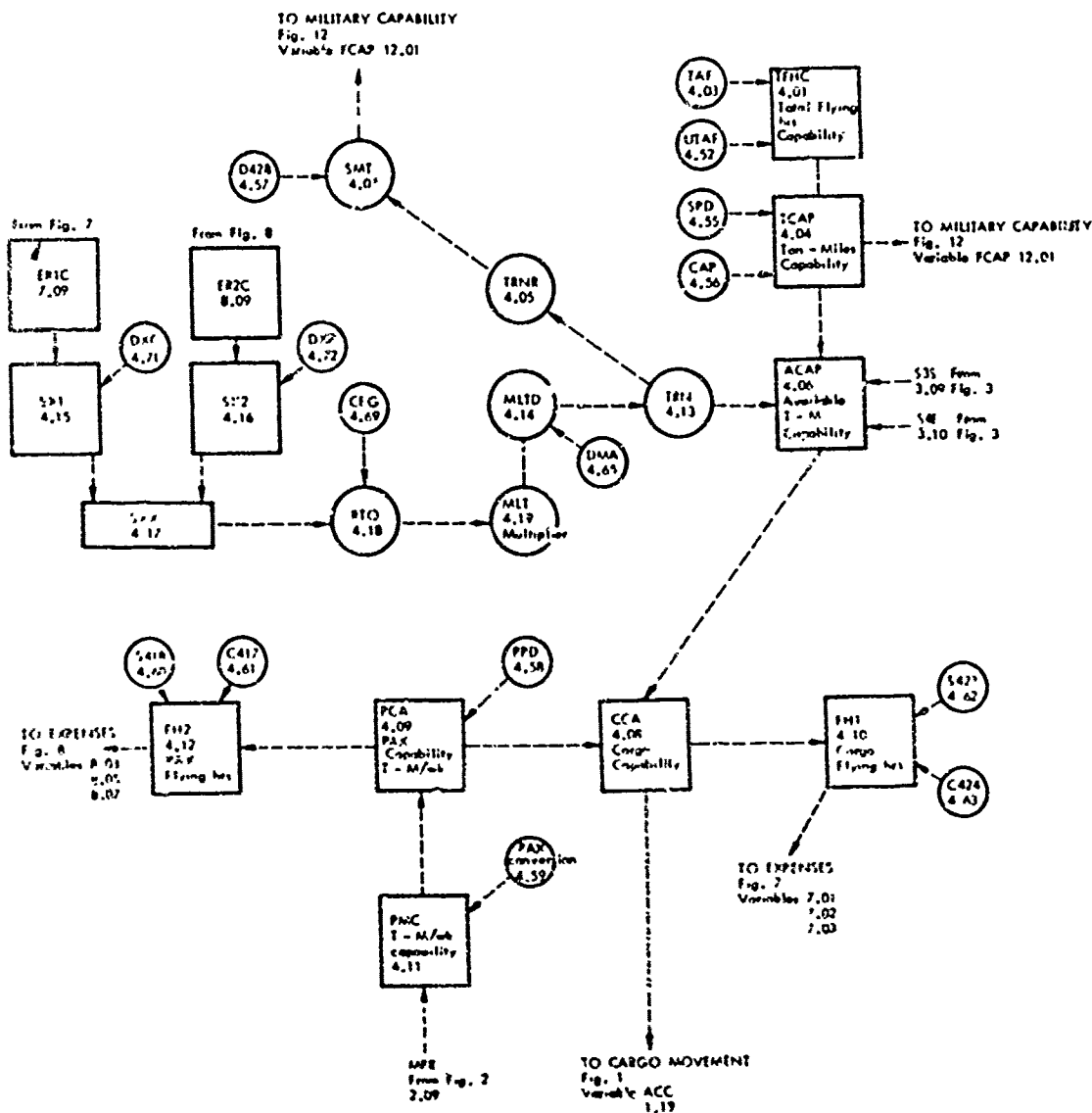


Figure 4. Model of Military Capability Allocation.

the following relationship between RTO and the multiplier MLT is assumed.

When RTO equals	1	or greater, MLT equals	1
" " "	0.9	MLT equals	1.1
" " "	0.8	" "	1.3
" " "	0.7	" "	1.5
" " "	0.6	" "	1.6
" " "	0.5	" "	1.8
" " "	0.4	" "	2.0
" " "	0.3	" "	2.3
" " "	0.2	" "	2.5
" " "	0.1	" "	3
" " "	0	" "	5

It is also assumed that the actual decision to change testing and training requirements would be based on the average multiplier, so the multiplier is smoothed over a one-week interval.

$$4.14 \quad \text{MLTD.K} = \text{MLTD.J} + (\text{DT/DMA}) (\text{MLT.J} - \text{MLTD.J})$$

MLTD = Multiplier delayed

$$4.65 \quad \text{DMA} = \text{Delay (weeks)}$$

The equation for TRN, testing and training, is now represented as follows:

$$4.13 \quad \text{TRN.K} = \text{TRNI} * \text{MLTD.K}$$

TRN = Testing and Training Requirement (Ton-Miles/week)

TRNI = Initial TRN Requirements (Ton-Miles/week)

The actual training rate is then

$$4.05 \quad \text{TRNR.KL} = \text{TRN.K}$$

TRNR = TRN Rate (Ton-Miles/week)

For forecasting purposes an averaged (smoothed) testing and training rate is calculated.

$$4.07 \quad \text{SMT.K} = \text{SMT.J} + (\text{DT/D428}) (\text{TRNR.JK} - \text{SMT.J})$$

SMT = Smoothed Testing and Training Requirements

$$4.57 \quad \text{D428} = \text{Delay in Smoothing (weeks)}$$

The actual military capability now available for moving Cargo and PAX requirements is the total capability (TCAP) less that capability allocated to SAAM (S3S), Exercise (S4E) and testing and training (TRN). This equation is written as follows:

$$4.66 \quad \text{ACAP.K} = \text{TCAP.K} - \text{S3S.JK} - \text{S4E.JK} - \text{TPN.K}$$

ACAP = Available Military Capability (Ton-Miles/week)

This quantity is now reduced by the capability allocated to PAX movement, variable MPR of Figure 2. This variable dimensionally was PAX-Miles/week and must first be converted to an equivalent Ton-Miles/week. This is modeled as follows:

$$4.11 \quad PMC.K = MPR.K * PAX$$

PMC = Military Capability Allocated to PAX (Ton-Miles/week)

$$4.59 \quad PAX = \text{Conversion Factor (Ton-Miles/PAX-Miles)}$$

This capacity is now reduced further by a PAX positioning and deposition factor (PPD).

$$4.00 \quad PCA.K = PMC.K * PPD$$

PCA = Total Military Capability required for PAX (Ton-Miles/week)

The Military Capability available for Cargo movement is now

$$4.08 \quad CCA.K = ACAP.K - PCA.K$$

CCA = Military Cargo Capability (Ton-Miles/week)

This variable, referenced earlier, is an input to Figure 1 to cover Cargo demand.

The MAC flying hours generated by PAX and Cargo movement are now calculated by converting Ton-Miles/week to flying hours by dividing by speed and capacity variables.

$$4.12 \quad FH2.K = PCA.K / ((S418)(C417))$$

$$4.10 \quad FH1.K = CCA.K / ((S423)(C424))$$

FH2 = Flying Hours-PAX - (Flying hours/week)

FH1 = Flying Hours-Cargo - (Flying hours/week)

$$4.60 \quad S418 = \text{Speed of Aircraft (MPH)}$$

$$4.62 \quad S423 = \text{Speed of Aircraft (MPH)}$$

$$4.61 \quad C417 = \text{Capacity of Aircraft (Tons)}$$

$$4.63 \quad C424 = \text{Capacity of Aircraft (Tons)}$$

This completes the identification of variables and equations for that segment of the model represented by Figure 4. This segment of the model has determined the military capability available and allocated it according to ASIF priorities to testing and training, SAAM, Exercise, PAX, and Cargo requirements.

A list of all variables identified in Figure 4 and their corresponding initial conditions and parameters is given in Appendix IV.

Figure 5

After a service has been provided by MAC, either moving cargo or passengers, the customer is then billed according to a tariff structure. Tariffs are calculated so as to provide income to the Industrial Fund sufficient to recover all Industrial Fund expenses. As noted earlier, the Industrial Fund is charged with "breaking even" over a two-year period.

In Figure 5 those variables which model the Industrial Fund manifesting and billing procedure are identified.

The Industrial Fund manifests covering cargo or passenger movement are initiated within the originating terminal at the time the material or passengers are shipped. The shipping rate for Cargo, PAX, SAAM, and Exercise as modeled in Figures 1, 2, and 3, is utilized to model the initiating of the flow of manifests from the terminal to the Numbered Air Force, and then to MAC Headquarters where customer billing takes place.

The processing of Industrial Fund manifests is assumed to be the same for Cargo, PAX, SAAM, and Exercise, so the modeling of each is similar. The Industrial Fund manifest rate is initiated by the shipment and is therefore equal to the shipping rate.

$$5.16 \quad MR1.KL = S1GT.K + S1CT.K$$

MR1 = Manifest rate-Cargo (Ton-Miles/week)

The terminal processes these manifests and sends them on to the Numbered Air Force.

$$5.01 \quad TP1.KL = \text{DELAY } 3(MR1.JK, D513)$$

$$5.50 \quad D513 = \text{Delay in processing (weeks)}$$

TP1 = Terminal processing rate-Cargo (Ton-Miles/week)

The Numbered Air Force, after processing, forwards the manifest on to MAC Headquarters for billing.

$$5.02 \quad FP1.KL = \text{DELAY } 3(TP1.K, D516)$$

$$5.51 \quad D516 = \text{Delay in processing (weeks)}$$

FP1 = Air Force processing rate-Cargo (Ton-Miles/week)

At MAC Headquarters the customer billing is performed based on manifests received from the Numbered Air Force.

$$5.03 \quad MP1.KL = \text{DELAY } 3(FP1.JK, D519)$$

$$5.52 \quad D519 = \text{Delay in processing (weeks)}$$

MP1 = MAC billing rate-Cargo (Ton-Miles/week)

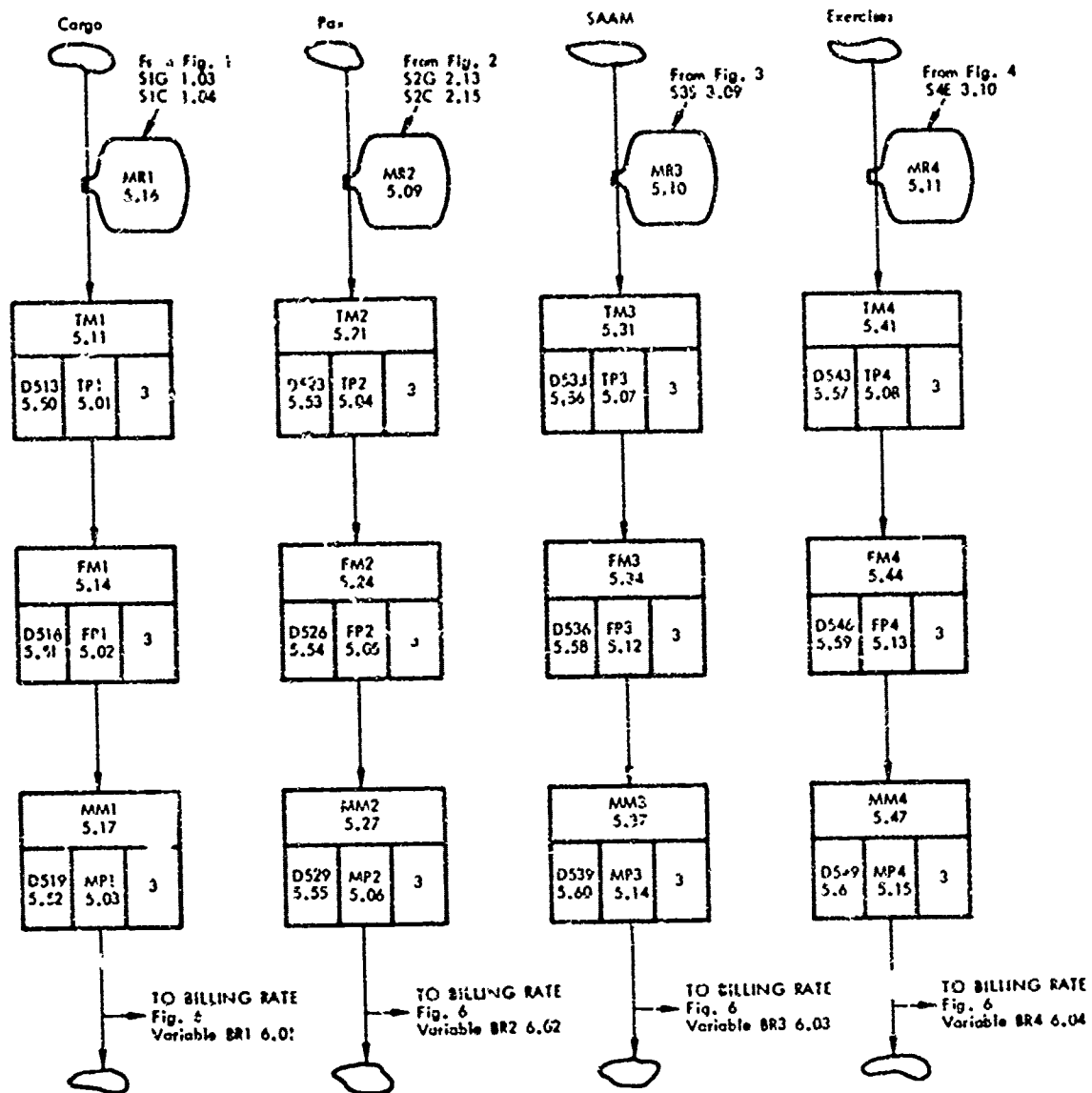


Figure 5. Model of Manifesting of Shipments

In each case it is assumed that a third order delay will replicate the relationship between work input rate and the dispersion of the work output rate.

The variables identified above and their equations represent the modeling of the Industrial Fund processing of Cargo manifests. The processing of PAX, SAAM, and Exercise manifests follow the same procedure and have been modeled in a similar manner. The resulting equations are as follows:

5.09 $MR2.KL = S2GT.K + S2CT.K$

MR2 = Manifest rate-PAX (PAX-Miles/week)

5.04 $TP2.KL = DELAY\ 3(MR2.JK, D523)$

5.53 $D523 = \text{Delay in processing (weeks)}$

TP2 = Terminal processing rate-PAX (PAX-Miles/week)

5.05 $FP2.KL = DELAY\ 3(TP2.JK, D526)$

5.54 $D526 = \text{Delay in processing (weeks)}$

FP2 = Air Force manifest processing rate-PAX (PAX-Miles/week)

5.06 $MP2.KL = DELAY\ 3(FP2.JK, D529)$

5.55 $D529 = \text{Delay in processing (weeks)}$

MP2 = MAC billing rate-PAX (PAX-Miles/week)

5.10 $MR3.KL = DELAY\ 3(IS3.JK, D34) *$

MR3 = Manifest rate-SAAM (Ton-Miles/week)

5.11 $MR4.KL = DELAY\ 3(IS4.JK, D316) *$

MR4 = Manifest rate-Exercise (Ton-Miles/week)

* (The manifest rate for SAAM and Exercise is also equal to the shipping rate for each service. See Figure 3 for equations for S3S and S4E.)

5.07 $TP3.KL = DELAY\ 3(MR3.JK, D533)$

5.08 $TP4.KL = DELAY\ 3(MR4.JK, D543)$

5.56 $D523 = \text{Delay in processing (weeks)}$

5.57 $D543 = \text{Delay in processing (weeks)}$

TP3 = Terminal processing rate-SAAM (Ton-Miles/week)

TP4 = Terminal processing rate-Exercise (Ton-Miles/week)

5.12 $FP3.KL = DELAY\ 3(TP3.JK, D536)$

5.13 $FP4.KL = DELAY\ 3(TP4.JK, D546)$

5.58 $D536 = \text{Delay in processing (weeks)}$

5.59 $D546 = \text{Delay in processing (weeks)}$

$FP3 = \text{Air Force processing rate-SAAM (Ton-Miles/week)}$

$FP4 = \text{Air Force processing rate-Exercise (Ton-Miles/week)}$

5.14 $MP3.KL = DELAY\ 3(FP3.JK, D539)$

5.15 $MP4.KL = DELAY\ 3(FP4.JK, D549)$

5.60 $D539 = \text{Delay in processing (weeks)}$

5.61 $D549 = \text{Delay in processing (weeks)}$

$MP3 = \text{MAC billing rate-SAAM (Ton-Miles/week)}$

$MP4 = \text{MAC billing rate-Exercise (Ton-Miles/week)}$

This completes the identification of those level and rate equations which represent the processing of Industrial Fund manifests after the customer's demand for Cargo, PAX, SAAM, or Exercise movement has been completed.

A list of all variables identified in Figure 5 and their corresponding initial conditions and parameters is given in Appendix V.

Figure 6

The final processing of the Industrial Fund manifest results in the customer billing. This is influenced by the tariffs for Cargo, PAX, SAAM, and Exercise movement. The customer billing results in an accounts receivable variable until the customer's payment is received. When payment is received, the Accounts Receivable variable is reduced and cash on hand is increased. The Industrial Fund also pays all expenses which have been generated in providing the MAC service.

In Figure 6 we have modeled this segment of the system. We identify and model the billing function as well as cash flow.

The billing rates from Figure 5 (MP1, MP2, MP3, and MP4) represented the completion of Industrial Fund manifests and were in Ton-Miles/week or PAX-Miles/week. Information from these variables with information about the tariff structure now enables us to determine the billing rates in \$/week.

The equations for determining the tariff variables will be described later. At the present time we identify them as follows:

11.69 $TRF1 = \text{Cargo Tariff (\$/Ton-mile)}$

11.70 $TRF2 = \text{PAX Tariff (\$/PAX-mile)}$

11.71 $TRF3 = \text{SAAM and Exercise Tariff (\$/Ton-mile)}$

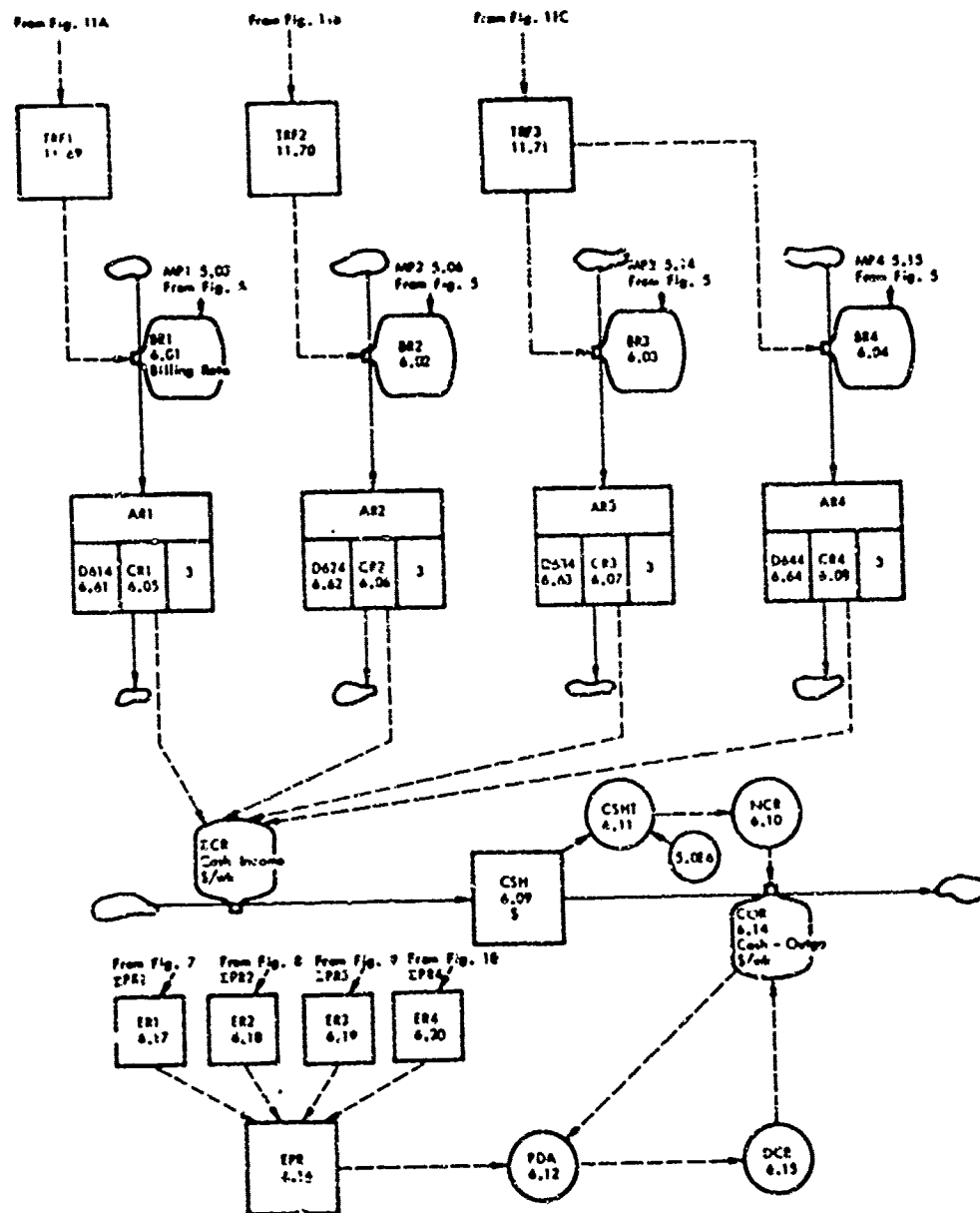


Figure 6. Model of Customer Billing and ASIF Cash Flow.

The customer billing rates in dollars/week are now identified by the following variables and their corresponding rate equations:

$$6.01 \quad BR1.KL = (TRF1.K) (MP1.JK)$$

$$6.02 \quad BR2.KL = (TRF2.K) (MP2.JK)$$

$$6.03 \quad BR3.KL = (TRF3.K) (MP3.JK)$$

$$6.04 \quad BR4.KL = (TRF4.K) (MP4.JK)$$

Variables AR1, AR2, AR3 and AR4 represent MAC Accounts Receivables. Rate equations 6.05, 6.06, 6.07 and 6.08 represent the customer's payment rates or cash receipt rate. A third order delay equation is assumed to represent the delay between customer billing and receipt of customer payment. Equations for the accounts receivable variables are not required.

AR1 = Accounts Receivable-Cargo (\$)

AR2 = Accounts Receivable-PAX (\$)

AR3 = Accounts Receivable-SAAM (\$)

AR4 = Accounts Receivable-Exercise (\$)

$$6.05 \quad CR1.KL = \text{DELAY } 3(BR1.JK, D614)$$

$$6.61 \quad D614 = \text{Delay in payment (weeks)}$$

$$6.06 \quad CR2.KL = \text{DELAY } 3(BR2.JK, D624)$$

$$6.07 \quad CR3.KL = \text{DELAY } 3(BR3.JK, D634)$$

$$6.08 \quad CR4.KL = \text{DELAY } 3(BR4.JK, D644)$$

$$6.62 \quad D624 = \text{Delay in payment (weeks)}$$

$$6.63 \quad D634 = \text{Delay in payment (weeks)}$$

$$6.64 \quad D644 = \text{Delay in payment (weeks)}$$

CR1 = Cash Receipt rate-Cargo (\$/week)

CR2 = Cash Receipt rate-PAX (\$/week)

CR3 = Cash Receipt rate-SAAM (\$/week)

CR4 = Cash Receipt rate-Exercise (\$/week)

The Cash Income Rate (CIR = \$/week) is the sum of variables 6.05, 6.06, 6.07, and 6.08 and the level of cash is then

$$6.09 \quad CSH.K = CSH.J + DT(CR1.JK + CR2.JK + CR3.JK + CR4.JK - COR.JK)$$

CSH = Cash (\$)

Equation 6.10 is a control device. The ASIF specifies that cash on hand should never go below \$5,000,000. The cash outgo rate can then never be such to reduce cash below this level. This boundary condition is modeled by the following equations.

$$6.11 \quad \text{CSHT.K} = (\text{CSH.K} - 5.0\text{E}6)$$

$$6.10 \quad \text{NCR.KL} = (\text{CSHT.K})/\text{DT}$$

CSHT = Cash available to pay accounts (\$)

NCR = Negative Cash Rate (\$/week)

If there is sufficient cash available, it is assumed that the past due account will be paid in full. If it is not, then the past due account is increased by unpaid accounts and payment tried the next time period.

The past due account at any time then will be a function of the previous past due account plus the sum of all expenses due for payment and less all expenses paid.

$$6.12 \quad \text{PDA.K} = \text{PDA.J} + \text{DT}(\text{EPR.J} - \text{COR.JK})$$

PDA = Past Due Account (\$)

EPR = Expense Payment Rate (\$/week)

COR = Cash Outgo Rate (\$/week)

The desired cash payment rate is then

$$6.15 \quad \text{DCR.K} = \text{PDA.K}/\text{DT}$$

DCR = Desired Cash Payment rate (\$/week)

The equation for Cash Outgo Rate (COR) is now the smaller of variables DCR.K and NCR.K.

$$6.14 \quad \text{COR.KL} = \text{MIN}(\text{DCR.K}, \text{NCR.JK})$$

The Expense Payment Rate (EPR) will be described after developing the equations and variables identifying the Industrial Fund expense rates, for it is the sum of all expense rates from Figures 7, 8, 9, & 10. (See pg. 39 of this report.)

A list of all variables identified in Figure 6 and their corresponding initial conditions and parameters is given in Appendix VI.

Figure 7

The modeling of that segment of the Industrial Fund system which represents the accounting for expenses and their payment was a difficult assignment. A number of simplifying assumptions have been made with the hope that the significant and dynamic aspects of the real system have not been disturbed.

Expenses are generated by the movement of Cargo, PAX, SAAM, and Exercise. All expenses are identified according to the demand classification and then are further segregated as being an Administrative, Base level, Depot, POL, or Commercial expense. (SAAM and Exercise do not generate commercial expense.)

Expenses are assumed to be a function of the number of flying hours generated and some constant charge each week. This function varies between Cargo, PAX, SAAM, and Exercise and between Administration, Base level, Depot and POL categories.

Figure 7 represents the model for Cargo expenses by expense category. The variables and variable equations for Cargo shipments will first be explained and PAX, SAAM, and Exercise variables and equations will be similar.

We have assumed that the expense rate is a function of a fixed cost and a variable cost which is a function of the flying hours generated. These expense rates generate the accounts payable account which is reduced by an expense payment rate. The expense payment rates are inputs which influence the past due account described and modeled in Figure 6. It has been assumed that the expense payment rates can be represented by 3rd order delay functions.

The accounts payable variable for each expense category is identified in Figure 7 in the following manner.

EP1A = Accounts Payable-Cargo-Administration (\$)

EP1B = Accounts Payable-Cargo-Base level (\$)

EP1D = Accounts Payable-Cargo-Depot (\$)

EP1P = Accounts Payable-Cargo-POL (\$)

EP1C = Accounts Payable-Cargo-Commercial (\$)

Administrative expenses are assumed to be a fixed cost each week. This cost is an exogenous input.

7.50 E710 = Expense rate (\$/week)

The expense rate is then

7.04 ER1A.KL = (E710)

7.05 PR1A.KL = DELAY 3(ER1A.JK, D713)

7.59 D713 = Delay in payment (weeks)

ER1A = Expense rate-Cargo-Administration (\$/week)

PR1A = Payment rate-Cargo-Administration (\$/week)

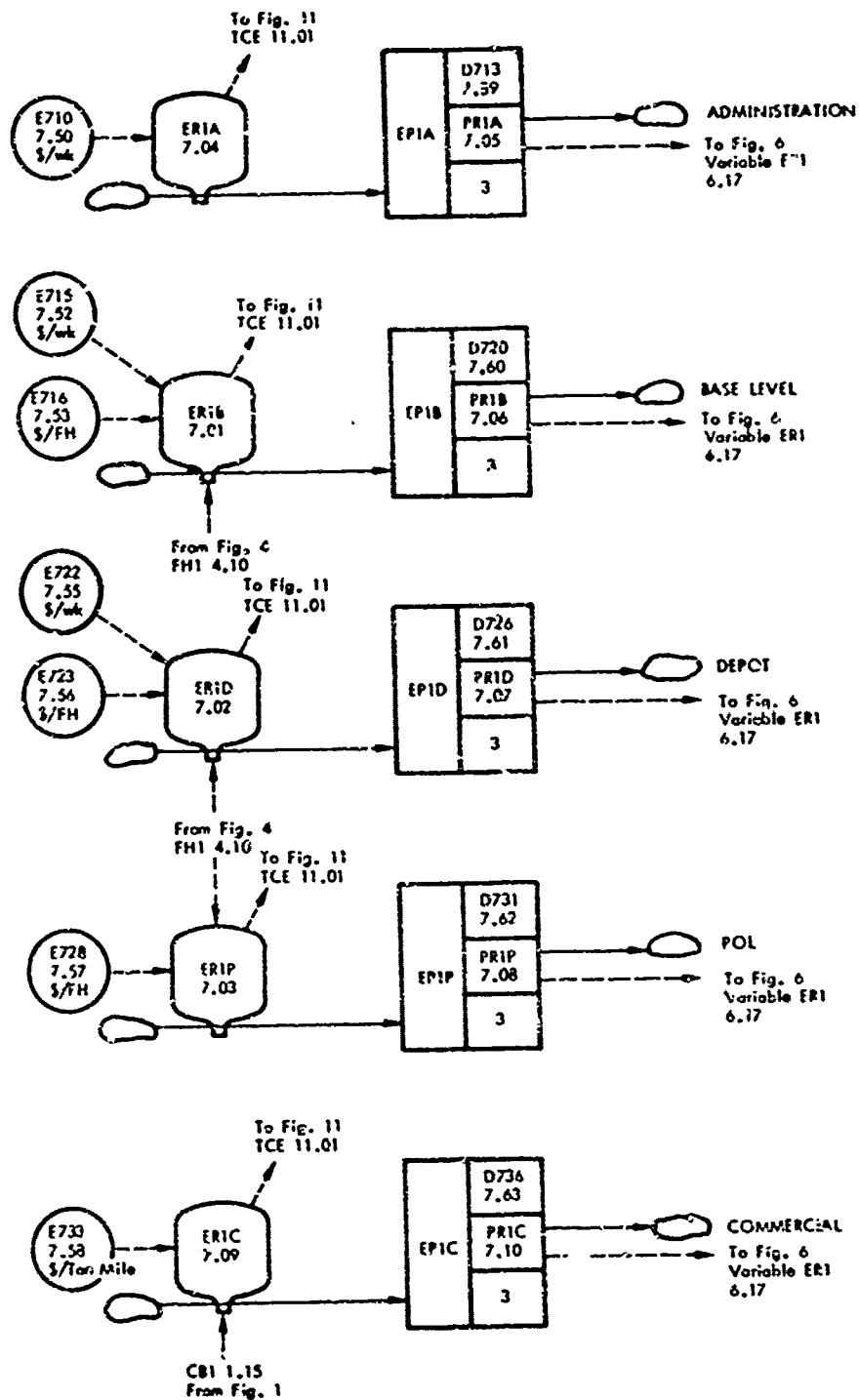


Figure 7. Model of Cargo Expenses

The base level expenses are a function of a fixed cost per week and the number of flying hours flown.

7.52 $E715 = \text{Expense rate } (\$/\text{week})$

7.53 $E716 = \text{Expense rate } (\$/\text{flying hour})$

The flying hours are obtained from that segment of the model described in Figure 4, equation 4.10.

7.01 $ER1B.KL = (E715) + (E716)(FHL.K)$

$ER1B = \text{Expense rate-Cargo-Base level } (\$/\text{week})$

7.06 $PR1B.KL = \text{DELAY } 3(ER1B.JK, D720)$

7.60 $D720 = \text{Delay in payment (weeks)}$

$PR1B = \text{Payment rate-Cargo-Base level } (\$/\text{week})$

Depot expenses are determined in a similar manner.

7.55 $E722 = \text{Expense rate } (\$/\text{week})$

7.56 $E723 = \text{Expense rate } (\$/\text{flying hour})$

7.02 $ER1D.KL = (E722) + (E723)(FHL.K)$

7.07 $PR1D.KL = \text{DELAY } 3(ER1D.JK, D726)$

7.61 $D726 = \text{Delay in payment (weeks)}$

$ER1D = \text{Expense rate-Cargo-Depot } (\$/\text{week})$

$PR1D = \text{Payment rate-Cargo-Depot } (\$/\text{week})$

The POL expenses are assumed to be influenced by only the number of flying hours generated.

7.57 $E728 = \text{Expense rate } (\$/\text{flying hours})$

7.03 $ER1P.KL = (E728)(FHL.K)$

7.08 $PR1P.KL = \text{DELAY } 3(ER1P.JK, D731)$

7.62 $D731 = \text{Delay in payment (weeks)}$

$ER1P = \text{Expense rate-Cargo-POL } (\$/\text{week})$

$PR1P = \text{Payment Rate-Cargo-POL } (\$/\text{week})$

The commercial expense is assumed to be based on the ton-miles moved by commercial contract.

7.58 $E733 = \text{Expense rate } (\$/\text{ton-miles})$

- 7.09 $(ER1C.KL) = (E733)(CB1.JK)$
7.10 $PR1C.KL = DELAY\ 3(ER1C.JK, D736)$
7.63 $D736 = \text{Delay in payment (weeks)}$

ER1C = Expense rate-Cargo-Commercial (\$/week)

PR1C = Payment rate-Cargo-Commercial (\$/week)

This completes the identification of those variables and their equations which represent that segment of the model covering expenses generated within the Industrial Fund when moving cargo for its customers. The equations for modeling expenses associated with the movement of PAX, SAAM and Exercise will be similar.

A list of all variables identified in Figure 7 and their corresponding initial conditions and parameters is given in Appendix VII.

Figure 8

Figure 8 shows those variables which represent that segment of the model representing the expenses associated with PAX movement. The equations are the same as for cargo movement (Figure 7) with the exception of the numeral 2, to represent PAX, in place of the numeral 1, which represented Cargo.

The accounts payable variables are

EP2A = Accounts Payable-PAX-Administration (\$)

EP2B = Accounts Payable-PAX-Base level (\$)

EP2D = Accounts Payable-PAX-Depot (\$)

EP2P = Accounts Payable-PAX-POL (\$)

EP2C = Accounts Payable-PAX-Commercial (\$)

- 8.50 $E810 = \text{Expense rate (\$/week)}$
8.51 $E815 = \text{Expense rate (\$/week)}$
8.52 $E816 = \text{Expense rate (\$/flying hour)}$
8.54 $E822 = \text{Expense rate (\$/week)}$
8.55 $E823 = \text{Expense rate (\$/flying hour)}$
8.56 $E828 = \text{Expense rate (\$/flying hour)}$
8.57 $E833 = \text{Expense rate (\$/PAX-miles)}$
8.01 $ER2A.KL = (E810)$
8.02 $PR2A.KL = DELAY\ 3(ER2A.JK, D813)$

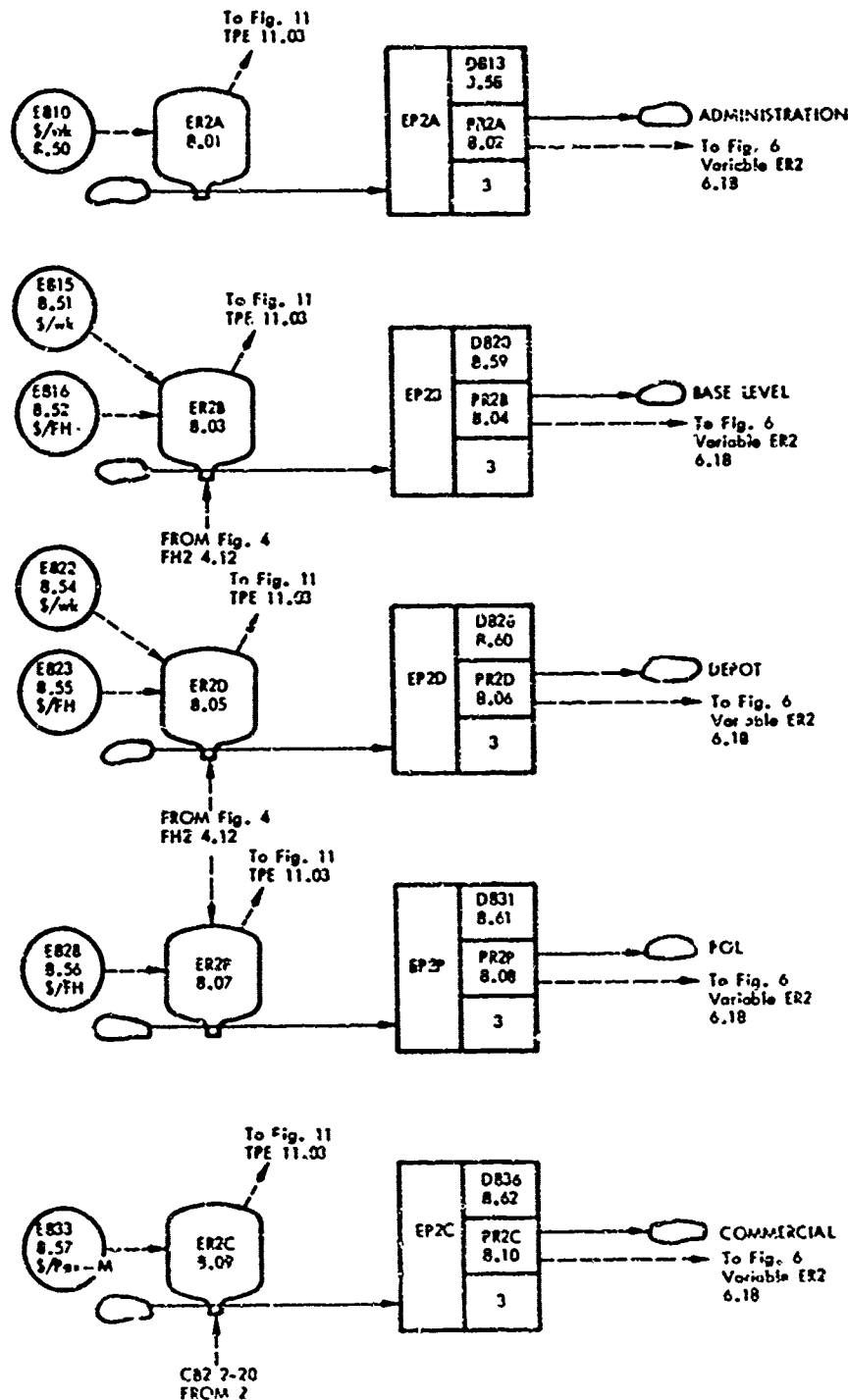


Figure 8. Model of PAX Expenses

Flying hours for PAX movement are obtained from variable 4.12 in Figure 4.

- 8.03 $ER2B.KL = (E815) + (E816)(FH2.K)$
- 8.04 $PR2B.KL = DELAY\ 3(ER2B.JK, D820)$
- 8.05 $ER2D.KL = (E822) + (E823)(FH2.K)$
- 8.06 $PR2D.KL = DELAY\ 3(ER2D.JK, D826)$
- 8.07 $ER2P.KL = (E828)(FH2.K)$
- 8.08 $PR2P.KL = DELAY\ 3(ER2P.JK, D831)$

The commercial buy in PAX-miles is represented by variable 2.20.

- 8.09 $ER2C.KL = (E833)(CB2.K)$
- 8.10 $PR2C.KL = DELAY\ 3(ER2C.JK, D836)$
- 8.58 $D813 = \text{Delay in payment (weeks)}$
- 8.59 $D820 = \text{Delay in payment (weeks)}$
- 8.60 $D826 = \text{Delay in payment (weeks)}$
- 8.61 $D831 = \text{Delay in payment (weeks)}$
- 8.62 $D836 = \text{Delay in payment (weeks)}$

A list of all variables identified in Figure 8 and their corresponding initial conditions and parameters is given in Appendix VIII.

Figure 9

Figure 9 identifies the variables representing the generation of Industrial Fund expenses associated with the movement of SAAM.

The variable equations differ from Cargo and PAX variables only by using the number 3 in the equations to represent SAAM.

The accounts payable variables are

- $EP3A = \text{Accounts Payable-SAAM-Administration } (\$)$
- $EP3B = \text{Accounts Payable-SAAM-Base level } (\$)$
- $EP3D = \text{Accounts Payable-SAAM-Depot } (\$)$
- $EP3P = \text{Accounts Payable-SAAM-POL } (\$)$

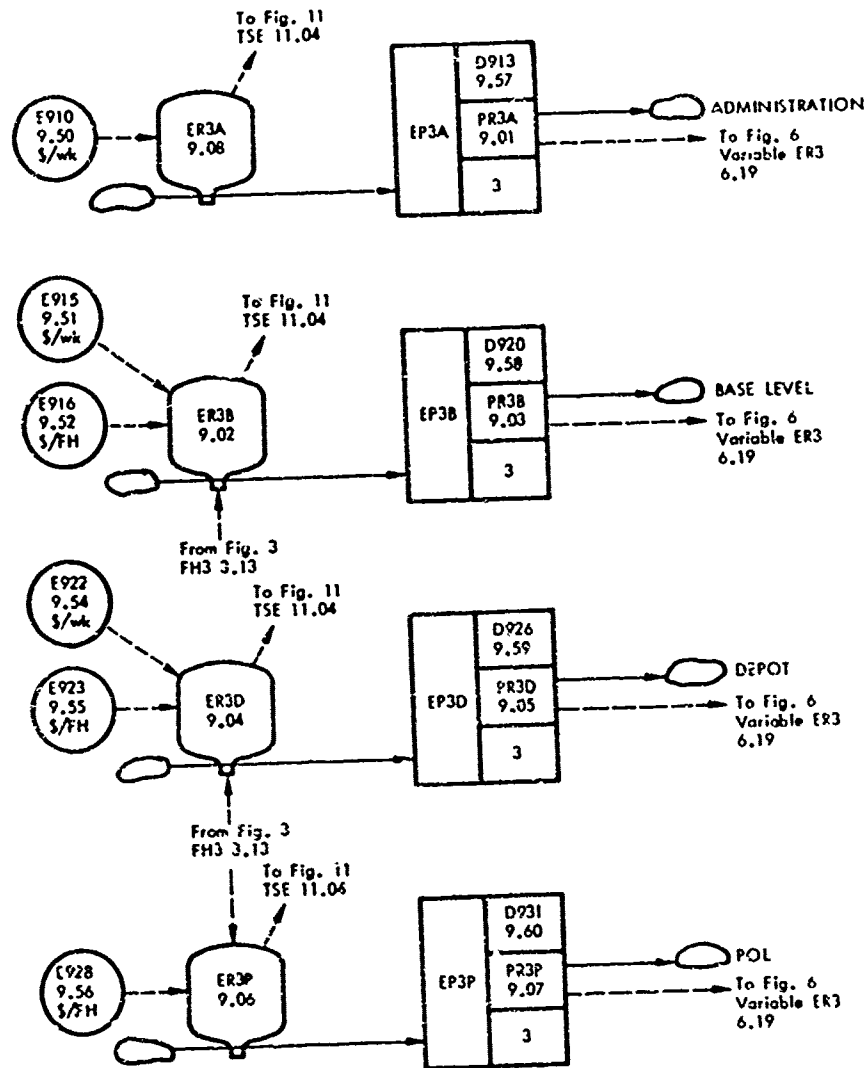


Figure 9. Model of SAAM Expenses

- 9.50 $E910 = \text{Expense rate-SAAM } (\$/\text{weeks})$
- 9.51 $E915 = \text{Expense rate-SAAM } (\$/\text{weeks})$
- 9.52 $E916 = \text{Expense rate-SAAM } (\$/\text{flying hour})$
- 9.54 $E922 = \text{Expense rate-SAAM } (\$/\text{weeks})$
- 9.55 $E923 = \text{Expense rate-SAAM } (\$/\text{flying hour})$
- 9.56 $E928 = \text{Expense rate-SAAM } (\$/\text{flying hour})$
- 9.57 $D913 = \text{Delay in payment (weeks)}$
- 9.58 $D920 = \text{Delay in payment (weeks)}$
- 9.59 $D926 = \text{Delay in payment (weeks)}$
- 9.60 $D931 = \text{Delay in payment (weeks)}$
- 9.08 $ER3A.KL = (E910)$
- 9.01 $PR3A.KL = \text{DELAY } 3(ER3A.JK, D913)$

Flying hours are obtained from variable 3.13 in Figure 3.

- 9.02 $ER3B.KL = (E915) + (E916)(FH3.K)$
- 9.03 $PR3B.KL = \text{DELAY } 3(ER3B.JK, D920)$
- 9.04 $ER3D.KL = (E922) + (E923)(FH3.K)$
- 9.05 $PR3D.KL = \text{DELAY } 3(ER3D.JK, D926)$
- 9.06 $ER3P.KL = (E928)(FH3.K)$
- 9.07 $PR3P.KL = \text{DELAY } 3(ER3P.JK, D931)$

A list of all variables identified in Figure 9 and their corresponding initial conditions and parameters is given in Appendix IX.

Figure 10

In the same manner, Figure 10 models those variables representing the generation of expenses associated with the movement of Exercises. The number 4 in the equations denotes an "Exercise" movement.

The accounts payable variables are

$EP4A = \text{Accounts Payable-Exercises-Administration } (\$)$

$EP4B = \text{Accounts Payable-Exercises-Base level } (\$)$

EP4D = Accounts Payable-Exercises-Depot (\$)

EP4P = Accounts Payable-Exercises-POL (\$)

- 10.50 ET10 = Expense rate (\$/week)
- 10.51 ET15 = Expense rate (\$/week)
- 10.52 ET16 = Expense rate (\$/flying hour)
- 10.54 ET22 = Expense rate (\$/week)
- 10.55 ET23 = Expense rate (\$/flying hour)
- 10.56 ET28 = Expense rate (\$/flying hour)
- 10.57 ET13 = Delay in payment (weeks)
- 10.58 ET20 = Delay in payment (weeks)
- 10.59 ET26 = Delay in payment (weeks)
- 10.60 ET31 = Delay in payment (weeks)
- 10.02 ER4A.KL = (ET10)

Flying hours are obtained from variable 3.14 in Figure 3.

- 10.03 PR4A.KI = DELAY 3(ER4A.JK, DT13)
- 10.01 ER4B.KI = (ET15) + (ET16)(FH4.K)
- 10.04 PR4B.KL = DELAY 3(ER4B.JK, DT20)
- 10.05 ER4D.KL = (ET22) + (ET23)(FH4.K)
- 10.06 PR4D.KL = DELAY 3(ER4D.JK, DT26)
- 10.07 ER4P.KL = (ET28)(FH4.K)
- 10.08 PR4P.KL = DELAY 3(ER4P.JK, DT31)

Earlier the variable EPR (6.16) was identified as the expense payment rate and equal to the summation of all expense rates from Figures 7, 8, 9, and 10.

Having now identified these variables, the expense payment rate (EPR) for Cargo, PAX, SAAM, and Exercise, identified in Figure 6, can now be expressed.

The Cargo expense payment rate (ER1) is the sum of the expense payment rates for Administration, Base level, Depot, POL, and commercial categories.

- 6.17 ER1.K = PR1A.JK + PR1B.JK + PR1D.JK + PR1P.JK + PR1C.JK

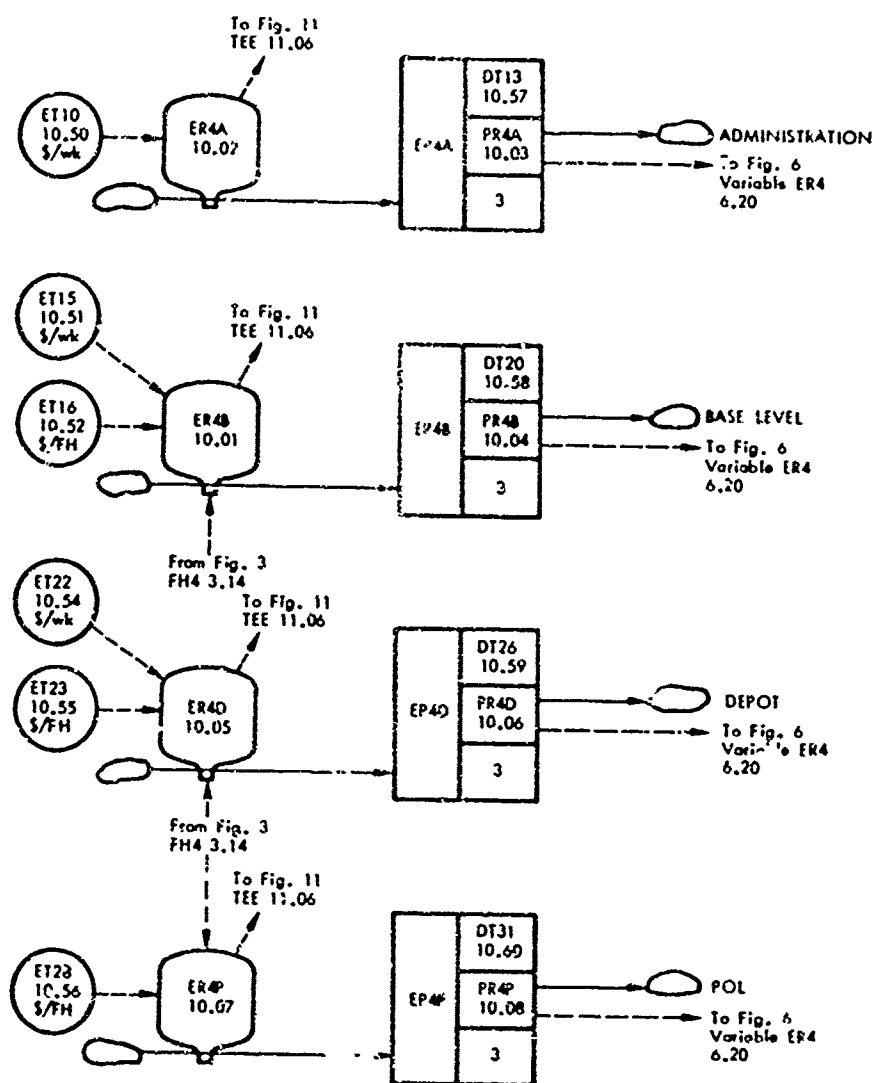


Figure 10. Model of Exercise Expenses

In the same manner

$$6.18 \quad ER2.K = PR2A.JK + PR2B.JK + PR2D.JK + PR2P.JK + PR2C.JK$$

$$6.19 \quad ER3.K = PR3A.JK + PR3B.JK + PR3D.JK + PR3P.JK$$

$$6.20 \quad ER4.K = PR4A.JK + PR4B.JK + PR4D.JK + PR4P.JK$$

ER1 = Cargo expense payment rate (\$/week)

ER2 = PAX expense payment rate (\$/week)

ER3 = SAAM expense payment rate (\$/week)

ER4 = Exercise expense payment rate (\$/week)

The expense payment rate for the Industrial Fund is then the sum of the above expense payment rates.

$$6.16 \quad EPR.K = ER1.K + ER2.K + ER3.K + ER4.K$$

A list of all variables identified in Figure 10 and their corresponding initial conditions and parameters is given in Appendix X.

Figure 11

The Industrial Fund is charged with recovering ASIF expenses without generating revenue in excess of expenses. While it is impossible and impractical to maintain revenues equal to expenses over short run time periods, the ASIF attempts to balance out total expenses and total revenue at the end of a specified time period. At the present this time period is two years.

In Figure 11 the tariff change decision is modeled. This decision is influenced by many factors and its modeling was difficult to achieve. As presently conceptualized and modeled, it is assumed that the decision to change the tariff is influenced by information from three sources.

First, it is assumed that the tariff will not be changed unless the difference between total revenues and total expenses is greater than some specified amount.

Second, it is assumed that the tariff will not be revised too frequently. That is, the tariff may not be revised oftener than every 3 months or every 6 months. This time period is modeled as a variable so the impact of different time periods may be studied.

Third, it is assumed that the tariff will not be changed unless the amount of change in tariff is greater than some minimum standard. That is, a 1% change in tariff may be deemed too small a change and delayed until it exceeds 2% or some larger figure.

The modeling of the tariff change decision function requires first a recording of total revenue and total expenses from time period 0. This information is derived from the billing function of Figure 6 and the expense

rate functions in Figures 7, 8, 9 and 10.

We determine first the total expenses generated for each classification of movement.

$$11.01 \quad TCE.K = TCE.J + DT(ER1A.JK + ER1B.JK + ER1D.JK + ER1P.JK + ER1C.JK)$$

TCE = Total Cargo Expenses (\$)

$$11.03 \quad TPE.K = TPE.J + DT(ER2A.JK + ER2B.JK + ER2D.JK + ER2P.JK + ER2C.JK)$$

TPE = Total PAX Expenses (\$)

$$11.04 \quad TSE.K = TSE.J + DT(ER3A.JK + ER3B.JK + ER3D.JK + ER3P.JK)$$

$$11.06 \quad TEE.K = TEE.J + DT(ER4A.JK + ER4B.JK + ER4D.JK + ER4P.JK)$$

TSE = Total SAAM Expenses (\$)

TEE = Total Exercise Expenses (\$)

The expense rates in the above equations are variables from Figures 7, 8, 9, and 10 as previously defined.

$$11.05 \quad TE.K = TCE.K + TPE.K + TEE.K + TSE.K$$

TE = Total Expenses = All ASIF (\$)

Total Income is derived from the same variables used to determine the billing rate.

For modeling purposes we wish to determine the level of income generated by the movement of material and passengers. We therefore utilize information on the manifest rate at the terminals to determine Industrial Fund income.

$$11.14 \quad MI1.K = (MR1.JK) (TRF1.K)$$

$$11.15 \quad MI2.K = (MR2.JK) (TRF2.K)$$

$$11.16 \quad MI3.K = (MR3.JK) (TRF3.K)$$

$$11.17 \quad MI4.K = (MR4.JK) (TRF4.K)$$

MI1 = Cargo Income Manifested (\$/week)

MI2 = PAX Income Manifested (\$/week)

MI3 = SAAM Income Manifested (\$/week)

MI4 = Exercise Income Manifested (\$/week)

The total income potential is then influenced by the above rates over time.

$$11.08 \quad TI.K = TI.J + (DT)(MI1.J + MI2.J + MI3.J + MI4.J)$$

That portion of the total income generated which was due to PAX movement is determined as follows

$$11.07 \quad TPI.K = TPI.J + DT * MI2.J$$

TPI = Total PAX Income (\$)

TI = Total Industrial Fund Income (\$)

The Industrial Fund, charged with breaking even over time, maintains an awareness of the differences between total income and total expenses. This awareness is based on differences in income and expenses generated by both PAX and Cargo (including SAAM and Exercise) movement.

The difference (between income and expenses) generated by PAX movement is determined as follows:

$$11.13 \quad PD.K = TPI.K - TPE.K$$

PD = PAX difference (\$)

Cargo expenses and income totals are assumed to be the difference between total ASIF expenses and income generated and those expenses and income allocated to PAX movement.

$$11.09 \quad TECI.K = TI.K - TPI.K$$

$$11.10 \quad TCEE.K = TE.K - TPE.K$$

TECI = Total Cargo & SAAM, Exercise Income (\$)

TCEE = Total Cargo & SAAM, Exercise Expenses (\$)

The difference (between income and expenses) generated by Cargo movement, including SAAM and Exercise, is now determined.

$$11.11 \quad CD.K = TECI.K - TCEE.K$$

CD = Cargo difference (\$)

For identification purposes and increased communication, we will refer to the difference between income and expenses as the "Out of Balance Condition", or the OBC. Thus, PD will be the OBC in PAX movement and CD the OBC created by Cargo, SAAM and Exercise movement.

We have assumed that the out of balance position between expenses and revenue for either Cargo or PAX will not influence a decision to revise the tariff unless the OBC exceeds some predetermined figure.

In the model of the Industrial Fund we have assumed that the allowable OBC is a function of the income rate. The ratio of the OBC to the average income is determined to represent this aspect of the decision function.

The average income is identified as the smoothed average income over a specified time period. Exponential averaging is again utilized.

$$\begin{aligned} 11.18 \quad & \text{SCI.K} = \text{SCI.J} + (\text{DT/DE15}) (\text{MI1.J} - \text{SCI.J}) \\ 11.19 \quad & \text{SPI.K} = \text{SPI.J} + (\text{DT/DE16}) (\text{MI2.J} - \text{SPI.J}) \\ 11.20 \quad & \text{SSEI.K} = \text{SSEI.J} + (\text{DT/DE17}) (\text{MI3.J} + \text{MI4.J} - \text{SSEI.J}) \\ 11.21 \quad & \text{SCEI.K} = \text{SCI.K} + \text{SSEI.K} \end{aligned}$$

SCI = Smoothed Cargo Income (\$/week)

SPI = Smoothed PAX Income (\$/week)

SSEI = Smoothed SAAM-Exercise Income (\$/week)

SCEI = Smoothed Cargo-SAAM-Exercise Income (\$/week)

DE15 = Delay in Smoothing (weeks)

DE16 = Delay in Smoothing (weeks)

DE17 = Delay in Smoothing (weeks)

The computation of a ratio of the OBC and the smoothed income gives an indication of the magnitude of the OBC compared to the average weekly income. In this basic model we have established the maximum OBC as one week of average income or a desired maximum ratio of 100. Variables 11.28 and 11.29 are the computed ratios and 11.139 and 11.140 the desired ratios.

$$11.28 \quad \text{RC.K} = (100) \text{CDX.K/SCEI.K}$$

$$11.29 \quad \text{RP.K} = (100) \text{PDX.K/SPI.K}$$

RC = Ratio-Cargo (%)

RP = Ratio-PAX (%)

$$11.139 \quad \text{DRC} = \text{Desired Ratio-Cargo} (\%)$$

$$11.140 \quad \text{DRP} = \text{Desired Ratio-PAX} (\%)$$

(Note: The variable CDX used in equation 11.28 is the same absolute quantity as the CD variable 11.11. CD may be positive or negative but in calculating the ratio RC only the absolute OBC is desired. Our model, therefore, includes two additional equations (11.30 & 11.32) to eliminate the possibility of a negative sign. The same is true for PDX and PD and equations 11.31 and 11.33 assure the absolute value of PD being used in the calculation of RP.K.)

It was indicated that the final decision to change the tariff is influenced by three factors.

- a) What is the degree of difference between expenses and income?
- b) How long has it been since the last tariff change?
- c) What magnitude of change is required?

The model must enable each of these three factors to be considered and all three must signal a tariff change before the new tariff is initiated.

The model of this decision function will be described for the Cargo tariff first. Those variables which are a part of this decision function and their relationship is modeled in Figure 11A.

This decision is being made at an instant in time and is assumed to be at time K. In another segment of the model the new proposed tariff has been determined and identified as TR1.K. We are deciding whether to use this tariff rate, or the tariff rate used during the previous time period which is identified as TT1.K.

TT1.K is equal to TRF1 of the last time period, or TRF1.J. The decision options are a) whether the tariff, TRF1.K, during this present time period will be the same as the tariff during the past time period and therefore equal to TRF1.J, or b) whether the tariff, TRF1.K, will be the forecasted tariff and therefore equal to TK1.K. As TRF1.J cannot be used directly in our modeling equations due to the Dynamo Compiler, a new variable, TT1.K, is established to identify the old tariff rate.

11.22 TTR1.KL = TRF1.K

11.25 TT1.K = TTR1.JK

Thus, equations 11.22 and 11.25 in effect establish TT1.K equal to TRF1.J.

In the same manner we calculate variables TT2 and TT3 which are equivalent to TRF2.J and TRF3.J respectively.

11.23 TTR2.KL = TRF2.K

11.26 TT2.K = TTR2.JK

11.24 TTR3.KL = TRF3.K

11.27 TT3.K = TTR3.JK

TT1 = Cargo Tariff rate during past time period (\$/Ton-mile)

TT2 = PAX Tariff rate during past time period (\$/Ton-mile)

TT3 = SAAM-Exercise Tariff rate during past time period (\$/Ton-mile)

The first step in the decision now compares RC with DRC. If RC is less than DRC the difference between total income and total expenses is not excessive and the past tariff rate (TT1.K) will be continued for the next time period. If the difference (RC) exceeds DRC, the new tariff rate (TR1.K) will be tried.

This step is modeled as follows:

11.34 FTT1.K = CLIP(TR1.K, TT1.K, RC.K, DRC)

FTT1 = First Tariff Try - Cargo

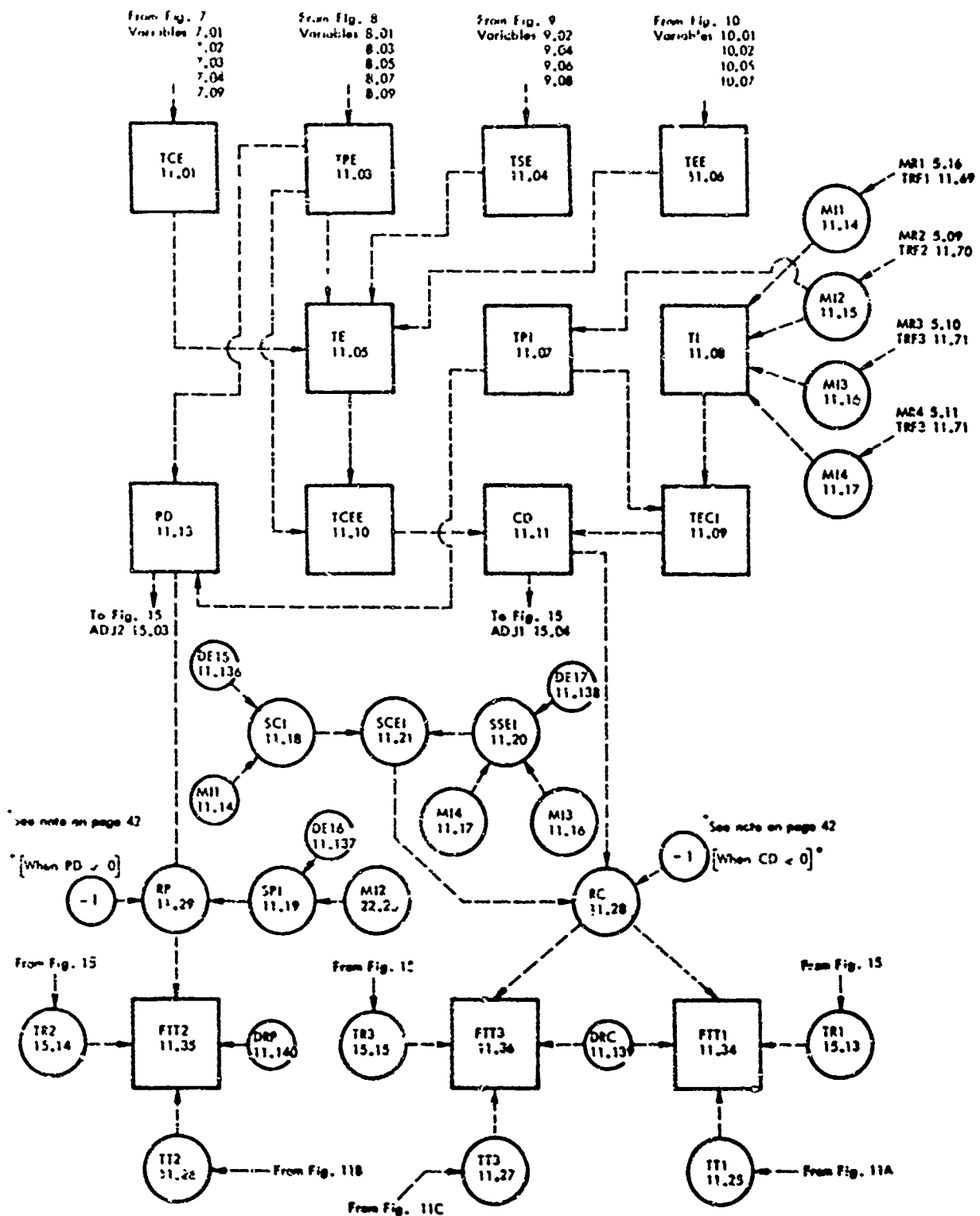


Figure 11. Model of Tarriff Change Decision.

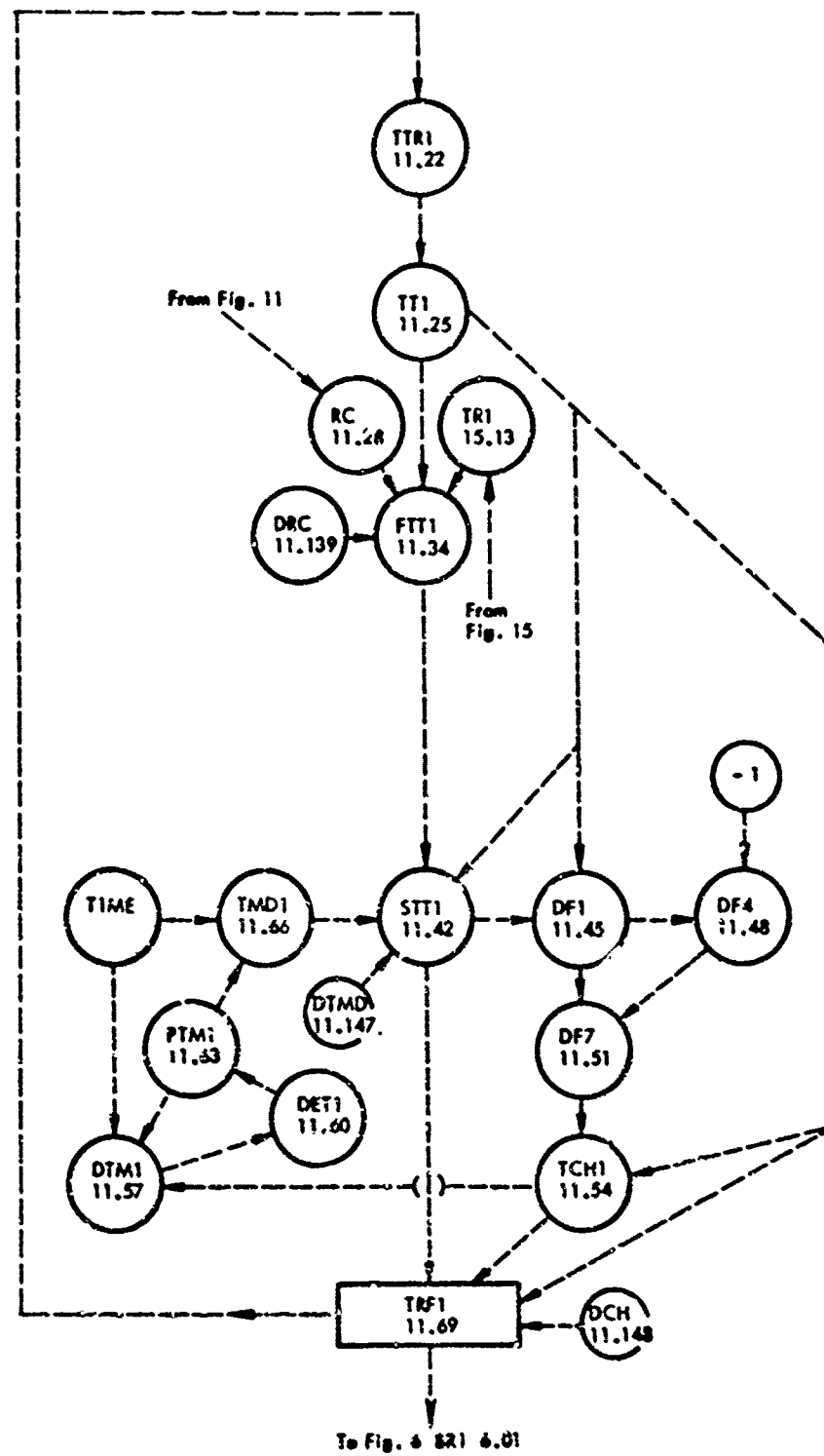


Figure 11A. Model of Cargo Tarriff Change.

The second step in the decision compares the period of time since the last decision to change the tariff with some desired minimum time period. The result of the first decision (FTT1) is again evaluated against the original or previous tariff (TT1). This assures that all three decisions must favor the tariff change before it is finally initiated.

This step is modeled as follows:

$$11.42 \quad STT1.K = CLIP(FTT1.K, TT1.K, TMD1.K, DTMD)$$

DTMD = Desired Time Delay in Changing Tariff (weeks)

TMD1 = Time Delay since Last Tariff Change (weeks)

STT1 = Second Tariff Try-Cargo

When the time since the last tariff change is less than that desired, the old tariff (TT1) will remain effective. However, when that time since the last change exceeds the desired time delay, the result of the first decision (FTT1) will be implemented.

The third step in the decision compares the magnitude of the tariff change proposed with some desired minimum change (DCH).

The tariff change being considered is determined by the following equation:

$$11.45 \quad DF1.K = STT1.K - TT1.K$$

This variable may be positive or negative but needs to be used as an absolute value for future calculation. Equation 11.48, variable DF4, establishes the opposite sign for the variable DF1 and the positive sign is then selected.

$$11.51 \quad DF7.K = MAX(DF1.K, DF4.K)$$

The degree of change proposed is then equal to the ratio of the change proposed to the old tariff.

$$11.54 \quad TCH1.K = (1/TT1.K)(DF7.K)$$

TCH = Tariff Change (Fraction)

The new tariff (TRF1) is now established as equal to the old tariff (TT1) if the degree of change (TCH1) is less than a desired minimum (DCH). The tariff (TRF1) will be set equal to the previous decision (STT1) if the tariff change exceeds the desired minimum. This is modeled as follows:

$$11.69 \quad TRF1.K = CLIP(STT1.K, TT1.K, TCH1.K, DCH)$$

TRF1 = Cargo Tariff (\$/Ton-miles)

The second decision (STT1) will be equal to the old tariff (TT1) unless both the out-of-balance position and the time constraints signaled for a tariff change. Thus, if this last test is passed, the new tariff will be initiated and the time of the last tariff change must be equated to the present

time. This is modeled as follows:

$$11.57 \quad DTM1.K = CLIP (TIME.K, PTM1.K, TCH1.K, DCH)$$

TIME = TIME into model run (weeks)

PTM1 = TIME of last tariff change (weeks)

Thus, if a tariff change is signaled as TCH1 is greater than DCH, then DTM1 is set equal to the present TIME. Otherwise, it is left equal to the time of the previous change (PTM1). Also,

$$11.60 \quad DET1.KL = DTM1.K$$

$$11.63 \quad PTM1.K = DET1.JK$$

The time since last change (TMD1) is then

$$11.66 \quad TMD1.K = TIME.K - PTM1.K$$

The above equations are replicated to model the decision function for determining whether the PAX tariff needs to be revised. (See Figure 11B) The equations for the PAX decision are as follows:

$$11.35 \quad FTT2.K = CLIP (TR2.K, TT2.K, RP.K, DRP)$$

$$11.43 \quad STT2.K = CLIP (FTT2.K, TT2.K, TMD2.K, DTMD)$$

$$11.46 \quad DF2.K = STT2.K - TT2.K$$

$$11.52 \quad DF8.K = MAX (DF2.K, DF5.K)$$

$$11.55 \quad TCH2.K = (1/TT2.K) (DF8.K)$$

$$11.70 \quad TRF2.K = CLIP (STT2.K, TT2.K, TCH2.K, DCH)$$

$$11.61 \quad DET2.KL = DTN2.K$$

$$11.64 \quad PTM2.K = DET2.JK$$

$$11.67 \quad TMD2.K = TIME.K - PTM2.K$$

In the same manner, equations for replicating the decision function for changing the SAAM and Exercise tariff are determined. (See Figure 11C)

$$11.36 \quad FTT3.K = CLIP (TR3.K, TT3.K, RC.K, DRC)$$

$$11.44 \quad STT3.K = CLIP (FTT3.K, TT3.K, TMD3.K, DTMD)$$

$$11.47 \quad DF3.K = STT3.K - TT3.K$$

$$11.53 \quad DF9.K = MAX (DF3.K, DF6.K)$$

$$11.56 \quad TCH3.K = (1/TT3.K) (DF9.K)$$

$$11.71 \quad TRF3.K = CLIP (STT3.K, TT3.K, TCH3.K, DCH)$$

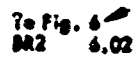


Figure 11B. Model of PAX Tarriff Change.

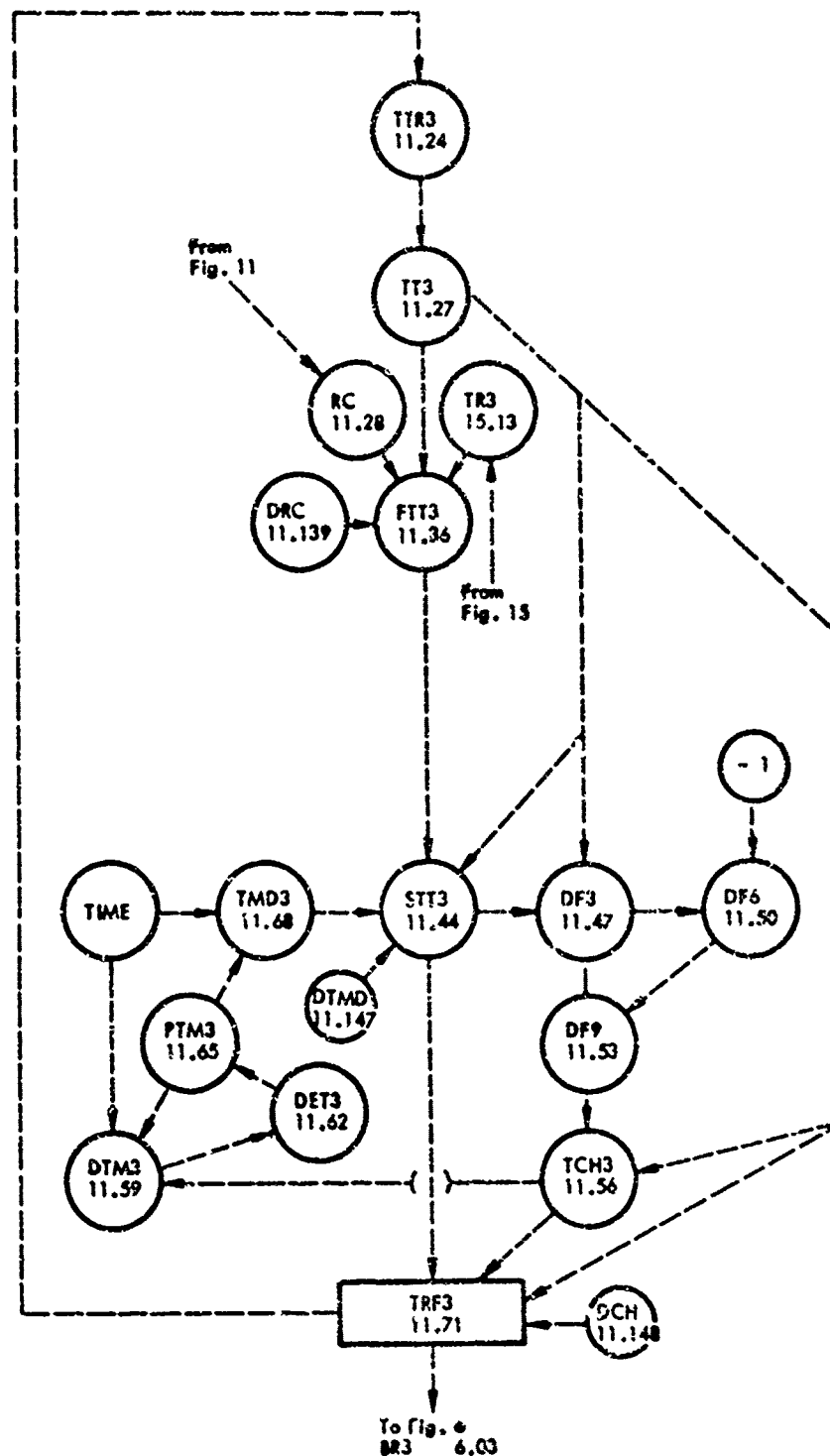


Figure 11C. Model of SAAM and Exercise Tariff Change.

- 11.59 $DTM3.K = CLIP (TIME.K, PTM3.K, TCH3.K, DCH)$
- 11.62 $DET3.KL = DTM3.K$
- 11.65 $PTM3.K = DET3.JK$
- 11.68 $TMD3.K = TIME.K - PTM3.K$

A list of all variables identified in Figure 11 and their corresponding initial conditions and parameters is given in Appendix XI.

Figure 12

The proposed tariffs (TR1, TR2, TR3) are determined after considering the forecasted demand for Cargo, PAX, SAAM and Exercise and allocating forecasted capabilities and expenses to each classification of demand. This has been modeled in three segments, one representing forecasted capability and its allocation, one the forecasted usage or demand, and finally the forecasted expenses. These variables then influence the proposed new tariff.

The modeling of forecasted military capability and its allocation to Cargo and PAX plus the determination of commercial requirements to cover any defects is basically a replication of Figure 4. Military capability is determined and allocated to Cargo and a portion of the PAX requirements (the major portion being covered by commercial buy) with the balance of the Cargo covered by additional commercial buy. This segment of the system is modeled in Figure 12.

The forecast military capability is based on the current capability available (variable 4.04) as modeled in Figure 4. This figure, reduced by forecasted SAAM and Exercise demand and forecasted test and training demand is identified as variable 12.01 and represents the total military capability available for forecast Cargo and PAX usage. (See Figure 13)

- 12.01 $FCAP.K = TCAP.K - SMT.K - FD34.K$

FCAP = Forecast Cargo - PAX Capability (Ton-Miles/week)

FD34 = Forecast SAAM-Exercise Requirement (Ton-Miles/week)

TCAP = Total Capability (Ton-Miles/week)

SMT = Smoothed testing and training (Ton-Miles/week)

From Figure 13 we obtain information regarding the portion of PAX requirements which are to be covered by military capability. This information is represented by variable F2A which is the difference between the total PAX forecasted requirements and the portion covered by commercial requirements.

- 12.05 $F2A.K = FD2X.K - FCB2.K$

F2A = PAX Demand covered by Military (PAX-Miles/week)

We convert this to ton-miles per week.

- 12.09 $FPR.K = F2A.K / FPAX$

FPAX = Conversion factor - (PAX-Miles per Ton-Miles)

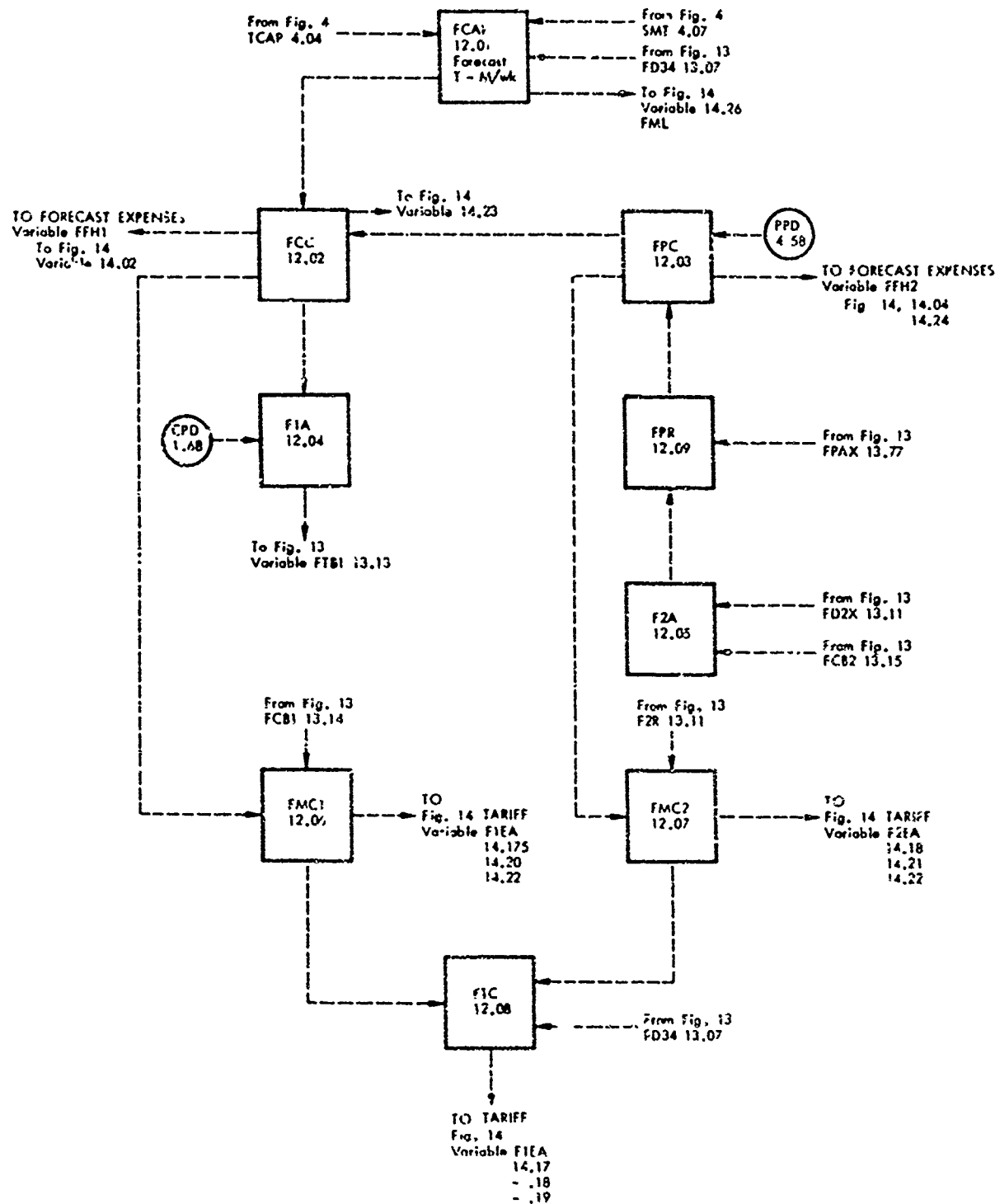


Figure 12. Model of Forecasted Capability Allocation

This requirement is then increased to cover positioning and deposition time.

$$12.03 \quad FPC.K = PPD * FPR.K$$

FPC = Military capability allocated to PAX (Ton-Miles/week)

The military capability allocated to Cargo is now the balance left after covering PAX requirements.

$$12.02 \quad FCC.K = FCAP.K - FPC.K$$

FCC = Military Capability allocated to Cargo (Ton-Miles/week)

This is reduced to allow for positioning and deposition time and the balance is used to cover the forecasted Cargo demand.

$$12.04 \quad F1A.K = CPD * FCC.K$$

F1A = Military Capability to cover Cargo Demand (Ton-Miles/week)

Variables 12.06, 12.07, and 12.08 are levels of information needed to calculate the forecasted tariff in Figure 14.

$$12.06 \quad FMCI.K = FCC.K + FCB1.K$$

FMCI = Forecast Military plus Commercial Cargo Capability (Ton-Miles/week)

$$12.07 \quad FMC2.K = FPC.K + F2R.K$$

FMC2 = Forecast Military plus Commercial PAX Capability (Ton-Miles/week)

$$12.08 \quad FTC.K = FMCI.K + FMC2.K + FD34.K$$

FTC = Forecast Total Commercial plus Military Capability including SAAM and Exercise (Ton-Miles/week)

A list of all variables identified in Figure 12 and their corresponding initial conditions and parameters is given in Appendix XII.

Figure 13

The Industrial Fund tariff is established to recover forecasted expenses and correct the OBC (Figure 11) over time from revenue anticipated from forecasted demand for MAC services. In the Industrial Fund system, forecasts come from the MAC customers. In our model of the system some method was needed to simulate this action. It was decided to assume that the forecasted demand for a service would be a function of

- a) the smoothed average demand over the past, and
- b) the smoothed average rate of change in demand over the past.

From Figure 1 and variables 1.17 and 1.18 the smoothed customer demand (SDIG and SDIC) is obtained for outgoing and incoming Cargo movement. Also, from Figure 1 information regarding the rate of change in customer demand

(SRIG and SRIC) is obtained from variables 1.22 and 1.23.

The Industrial Fund has a charge to break even (total expense = total revenue) over two-year intervals. It was therefore assumed that the system first attempts to break even when TIME = 2 years and will adjust tariffs as necessary to achieve this objective until TIME = 1 year at which time the system selects a new break even point as TIME = 3 years. The time for breaking even is therefore always between 1 and 2 years in the future. This prevents tariffs from becoming much too high or too low because of a short time interval for correcting the OBC.

Thus, from time 0 until the end of year 1 the adjustment point is the end of year 2. From the start of year 2 until the end of year 2, the adjustment point is the end of year 3. This information is modeled as follows:

The adjustment point in the future is equal to XYZ.

$$15.18 \quad XYZ.K = XYZI + TIS.K$$

$$XYZI = 104 \text{ weeks (2 years)}$$

This point is updated each year by TIS, which increases XYZ by 52 weeks at the end of each year, thereby always keeping the adjustment point sometime between one and two years in the future. (See variable 15.19 of Appendix XV)

The forecasted change in demand is now assumed to be the average change from the present until the end of adjustment period. This is given by the variable

$$13.19 \quad GI.G.K = (SRIG.K)(TIM.K)/2$$

$$15.01 \quad TIM.K = XYZ.K - TIME.K$$

TIM = Adjustment Period (weeks)

GI.G = Average change in Cargo demand-outgoing- over adjustment period
(Ton-Miles/week)

TIME = Present time in simulated run

The forecasted demand rate for the adjustment period is now the average demand plus the change in demand forecasted. This demand is also increased to allow for less than 100% utilization of the air frames capacity.

$$FDIG.K = (1/FULG)(SDIG.K + GI.G.K)$$

Forecasts can be in error and so, as to be able to test the sensitivity of the system to forecasting errors, we have introduced a noise function in the forecast. This is accomplished by multiplying the forecast by random numbers from a normal distribution. To dampen out the high frequency noise we then average (smooth) the results. This results in the following equations in place of the one given above for FDIG.

- 13.01 $FFD1G.K = (1/FU1G)(SD1G.K + G1G.K)$
13.25 $SF1G.K = (FFD1G.K) \text{ NORMRN } (MEAN, STDV2)$
13.31 $FD1G.K = \text{SMOOTH } (SF1G.K, DEF2)$

$FD1G$ = Forecasted Demand-Cargo-Outgoing (Ton-Miles/week)

- 13.62 $DEF2$ = Smoothing Time Period

In the above equations NORMRN (MEAN, STDV2) results in the Dynamo Compiler selecting random numbers from a normal distribution with a mean of MEAN and a standard deviation of STDV2. With various specifications for MEAN and STDV2, we are able to simulate random variation in the forecasted demand FFD1G.

The above equations represent the forecast for outgoing Cargo. Incoming Cargo is forecasted in the same manner.

- 13.20 $G1C.K = (SR1C.K)(TIM.K)/2$
13.02 $FFD1C.K = (1/FU1C)(SD1C.K + G1C.K)$
13.26 $SF1C.K = (FFD1C.K) \text{ NORMRN } (MEAN, STDV3)$
13.32 $FD1C.K = \text{SMOOTH } (SF1C.K, DEF3)$

$G1C$ = Average Change in Cargo incoming over adjustment period (Ton-Miles/week)

$FD1C$ = Forecasted Demand-Cargo-Incoming (Ton-Miles/week)

- 13.63 $DEF3$ = Smoothing Time Period

In the same manner the equations for forecasted PAX outgoing and incoming requirements are determined.

- 13.21 $G2G.K = (SR2G.K)(TIM.K)/2$
13.22 $G2C.K = (SR2C.K)(TIM.K)/2$
13.03 $FFD2G.K = (1/FU2G)(SD2G.K + G2G.K)$
13.04 $FFD2C.K = (1/FU2C)(SD2C.K + G2C.K)$
13.27 $SF2G.K = (FFD2G.K) \text{ NORMRN } (MEAN, STDV4)$
13.28 $SF2C.K = (FFD2C.K) \text{ NORMRN } (MEAN, STDV5)$
13.34 $FD2G.K = \text{SMOOTH } (SF2G.K, DEF4)$
13.33 $FD2C.K = \text{SMOOTH } (SF2C.K, DEF5)$

$G2G$ = Average Change in PAX-Outgoing over adjustment period (PAX-Miles/week)

$G2C$ = Average Change in PAX-Incoming over adjustment period (PAX-Miles/week)

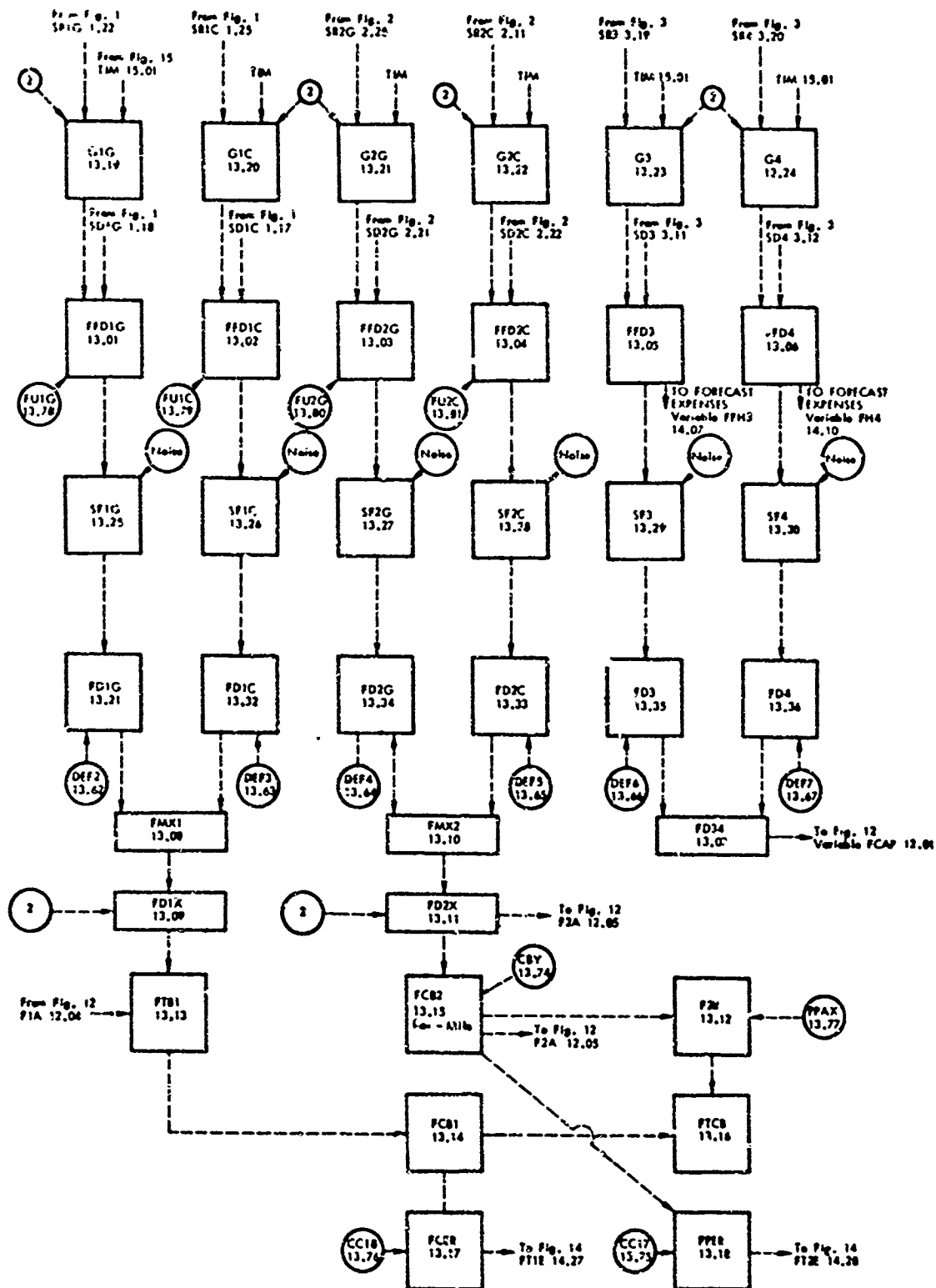


Figure 13. Model of Forecast Demand.

FD2G = Forecasted Demand-PAX-Outgoing (PAX-Miles/week)

FD2C = Forecasted Demand-PAX-Incoming (PAX-Miles/week)

13.64 DEF4 = Smoothing Time Period

13.65 DEF5 = Smoothing Time Period

SAAM and Exercise Demand is treated in this same manner.

13.23 C3.K = (SR3.K)(TIM.K) / 2

13.24 G4.K = (SR4.K)(TIM.K) / 2

13.05 FFD3.K = SD3.K + G3.K

13.06 FFD4.K = SD4.K + G4.K

13.29 SF3.K = (FFD3.K) NORMRN (MEAN, STDV5)

13.30 SF4.K = (FFD4.K) NORMRN (MEAN, STDV7)

13.35 FD3.K = SMOOTH (SF3.K, DEF6)

13.36 FD4.K = SMOOTH (SF4.K, DEF7)

G3 = Average Change in SAAM over adjustment period (Ton-Miles/week)

G4 = Average Change in Exercise over adjustment period (Ton-Miles/week)

FD3 = Forecasted Demand-SAAM-(Ton-Miles/week)

FD4 = Forecasted Demand-Exercise-(Ton-Miles/week)

13.66 DEF6 = Smoothing Time Period

13.67 DEF7 = Smoothing Time Period

The forecasted demand for SAAM and Exercise is then

13.07 FD34.K = FD3.K + FD4.K

FD34 = Total SAAM-Exercise Demand (Ton-Miles/week)

[This information (FD34) was utilized in Figure 12 to determine total military capability available for Cargo and PAX (FCAP).]

The forecasted Cargo capability is now assumed to be twice the larger demand between outgoing and incoming.

13.08 FMX1.K = MAX(FD1G.K, FD1C.K)

13.09 FD1X.K = 2 * FMX1.K

13.10 $FMX2.K = MAX(FD2G.K, FD2C.K)$

13.11 $FD2X.K = 2 * FMX2.K$

FD1X = Forecasted military capability demanded-Cargo (Ton-Miles/week)

FD2X = Forecasted military capability demanded-PAX (PAX-Miles/week)

The Industrial Fund covers the major portion of FAX demand by commercial buy. Thus,

13.15 $FCB2.K = FD2X.K * CBY$

FCB2 = Forecasted Commercial Buy-PAX (PAX-Miles/week)

13.74 $CRY = \% \text{ of Demand covered by Commercial Buy}$

The forecasted cost of the commercial buy is now

13.18 $FPER.K = CC17 * FCB2.K$

FPER = Forecasted cost of PAX buy (\$/week)

13.75 $CC17 = \text{Commercial cost } (\$/\text{PAX-Mile})$

The Cargo demand (FD1X) is covered by military capability (F1A from Figure 12) and the additional required, covered by commercial buy. If no commercial is required, the total military capability is utilized for the forecasted demand.

13.13 $FTB1.K = FD1X.K - F1A.K$

13.14 $FCB1.K = CLIP(FTB1.K, 0, FTB1.K, 0)$

The above two equations assure us that our model will purchase commercial time only when the demand (FD1X) exceeds the military capability (F1A).

FCB1 = Forecasted Commercial Buy-Cargo (Ton-Miles/week)

The total commercial buy in ton-miles per week is now computed by converting PAX buy to ton-miles per week and adding this to the Cargo commercial buy.

13.12 $F2R.K = FCB2.K / FPAX$

13.77 $FPAX = \text{Conversion Factor PAX-Miles/Ton-Miles}$

F2R = Forecasted PAX Commercial Buy (Ton-Miles/week)

13.16 $FTCB.K = FCB1.K + F2R.K$

FTCB = Forecasted Total Commercial Buy (Ton-Miles/week)

The forecasted cost for Cargo commercial buy is found as follows:

$$13.17 \quad FCER.K = CC18 * FCB1.K$$

FCER = Forecasted commercial cost-Cargo (\$/week)

$$13.76 \quad CC18 = \text{Commercial Tariff } (\$/\text{Ton-mile})$$

A list of all variables identified in Figure 13 and their corresponding initial conditions and parameters is given in Appendix XIII.

Figure 14

In Figures 14, 14A, and 15 we model that segment of the Industrial Fund system which determines the forecasted tariffs (TR1, TR2, TR3) at a point in time based on the forecasted customer usage, the forecasted expenses, and the Industrial Fund's total expense-revenue balance (OBC).

The forecasted customer usage has been modeled and described in Figure 13. From Figure 12 and the model of military capability allocation we obtain the forecasted military capability allocated to Passenger demand (FPC) and the forecasted military capability allocated to Cargo demand (FCC). From Figure 13 we obtain the forecasted SAAM requirements (FD3) and the forecasted Exercise requirements (FD4). These variables (FPC, FCC, FD3, FD4) influence the forecasted expenses associated with filling this forecasted demand.

The modeling of forecasted expenses (Figure 14A) is a replication of the modeling of actual expenses, the only difference being the use of forecasted flying hours rather than generated flying hours.

The flying hours are determined by dividing the military capability allocated by speed and capacity factors. Thus,

$$\begin{aligned} \text{Forecasted Flying Hours} &= \frac{\text{Forecasted Capability}}{(\text{speed})(\text{capacity})} \\ \text{Hrs./Week} &= \frac{\text{Ton-Miles/week}}{(\text{Miles/hr.})(\text{Tons})} \end{aligned}$$

$$14.04 \quad FFH2.K = FPC.K / ((S418)(C417))$$

$$14.02 \quad FFH1.K = FCC.K / ((S423)(C424))$$

$$14.07 \quad FFH3.K = FD3.K / ((SPD3)(CAP3))$$

$$14.10 \quad FFH4.K = FD4.K / ((SPD4)(CAP4))$$

FFH1.K = Forecasted Flying Hours allocated to Cargo (Flying Hours/week)

FFH2.K = Forecasted Flying Hours allocated to Passengers (Flying Hours/week)

FFH3.K = Forecasted Flying Hours allocated to SAAM (Flying Hours/week)

FFH4.K = Forecasted Flying Hours allocated to Exercise (Flying Hours/week)

S418, S423, SPD3, & SPD4 = Speed of Aircraft (Miles/Hour)

C417, C424, CAP3, & CAP4 = Capacity of Air Frame (Tons)

The forecasted expense rate per week is then the costs per flying hours multiplied by the flying hours per week plus the fixed costs per week.

The forecasted expense rate for Cargo is then

$$14.03 \quad FHE1.K = FFH1.K (E716 + E728 + E723)$$

$$14.01 \quad F1E.K = E710 + E715 + E722 + FHE1.K$$

FHE1.K = Forecasted Variable Cargo Expenses (\$/week)

F1E.K = Forecasted Total Cargo Expenses (\$/week)

The forecasted expenses for PAX, SAAM and Exercise movement is similarly modeled.

$$14.05 \quad FHE2.K = FFH2.K (E823 + E816 + E828)$$

$$14.06 \quad F2E.K = E810 + E815 + E822 + FHE2.K$$

$$14.08 \quad FHE3.K = FFH3.K (E916 + E923 + E928)$$

$$14.09 \quad F3E.K = E910 + E915 + E922 + FHE3.K$$

$$14.11 \quad FHE4.K = FFH4.K (ET16 + ET23 + ET28)$$

$$14.12 \quad F4E.K = ET10 + ET15 + ET22 + FHE4.K$$

FHE2 = Forecasted Variable PAX Expense (\$/week)

FHE3 = Forecasted Variable SAAM Expense (\$/week)

FHE4 = Forecasted Variable Exercise Expense (\$/week)

F2E = Forecasted Total PAX Expense (\$/week)

F3E = Forecasted Total SAAM Expense (\$/week)

F4E = Forecasted Total Exercise Expense (\$/week)

The total forecasted expense rate for all military capability is then

$$14.13 \quad FFTE.K = F1E.K + F2E.K + F3E.K + F4E.K$$

The above variable does not allow for possible errors in forecasting, as the expense rates used are actual rates not known in actuality until after the fact. Possible forecasting error or noise is introduced by a noise

function (see Figure 14) as follows:

$$14.14 \quad FTE.K = (FFTE.K) \text{ NORMRN } (MEAN, STDV1)$$

FTE = Forecasted Total Military Expense (\$/week)

MEAN = Mean of Error Deviation

STDV1 = Standard Deviation of Error

So as to prevent the forecasted expense from fluctuating with high frequency, as it would using the above equation, we smooth the results of the above equation to give the quantity used in forecasting the tariff.

$$14.15 \quad SFTE.K = \text{SMOOTH } (FTE.K, DEF1)$$

SFTE = Smoothed total expense rate (\$/week)

$$14.52 \quad DEF1 = \text{Smoothing time interval (weeks)}$$

The above equations now allow the analyst to introduce error in that portion of the model yielding the forecasted military expense rate. The sensitivity of the model, and possibly the system, to errors in expense forecasting may now be studied.

The total forecasted military expenses are now divided into three parts and each appropriately identified as either administrative expense rate, terminal expense rate, or direct expense rate. This is modeled with each variable considered a percentage of the total expense.

$$14.30 \quad DTE.K = SFTE.K * PCT4$$

$$14.31 \quad ADE.K = SFTE.K * PCT2$$

$$14.16 \quad TEX.K = SFTE.K * PCT3$$

ADE = Forecasted Administration expense rate (\$/week)

TEX = Forecasted Terminal expense rate (\$/week)

DTE = Forecasted Direct expense rate (\$/week)

$$14.53 \quad PCT2 = \% \text{ of total expense to Administration}$$

$$14.54 \quad PCT3 = \% \text{ of total expense to Terminal}$$

$$14.55 \quad PCT4 = \% \text{ of total expense to Direct}$$

In addition to the above forecasted military expenses, the forecasted commercial expense rate for Cargo (FCER) and Passengers (FPER) has also been determined in that segment of the model described in Figure 12.

The Industrial Fund determines the proposed tariff for each of the four types of demand by allocating costs to each classification of demand and recovering this cost based on the forecasted demand. The allocation of expenses to each demand classification is proportional to the capability allocated to that demand.

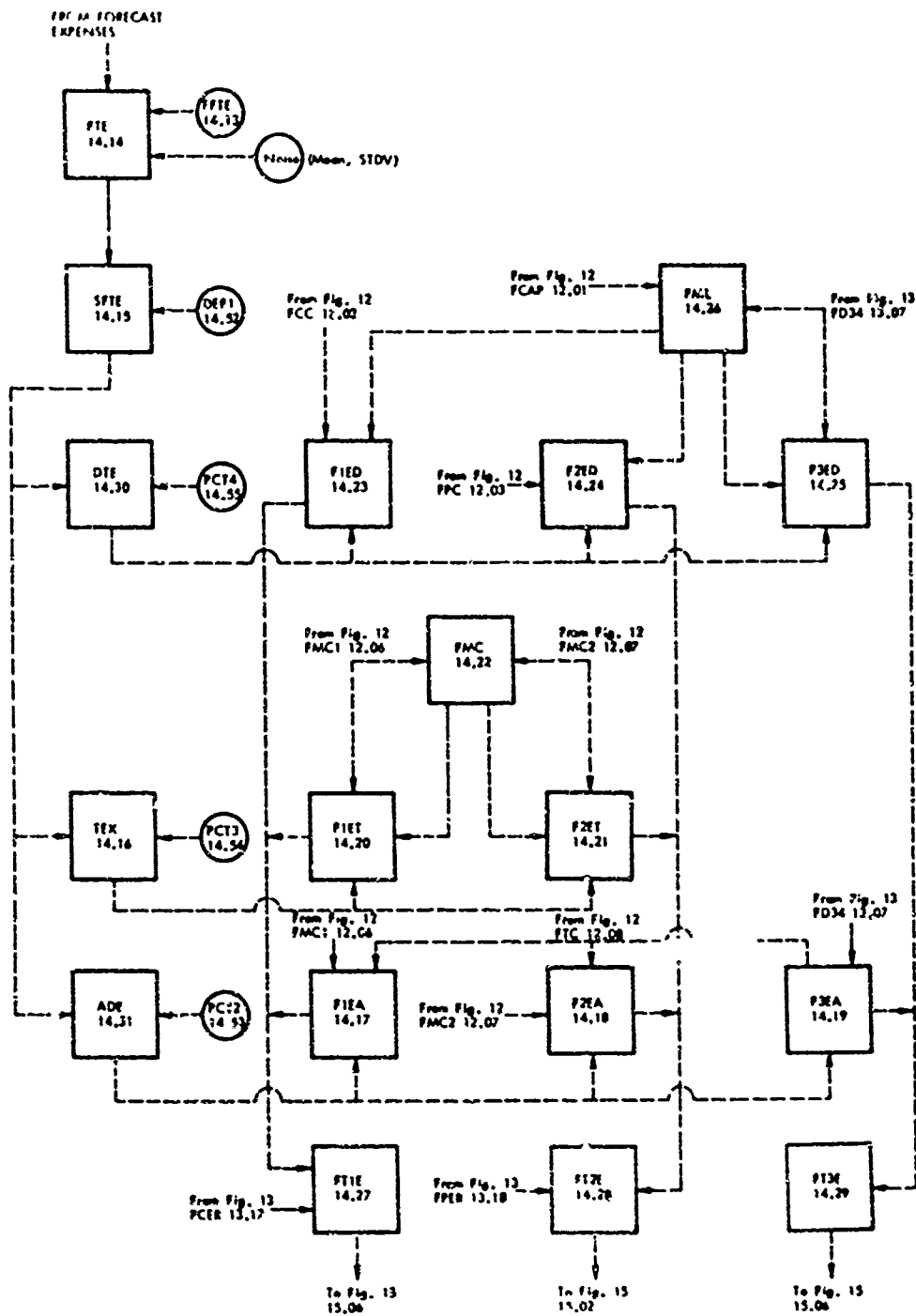


Figure 14. Model of Expense Allocation.

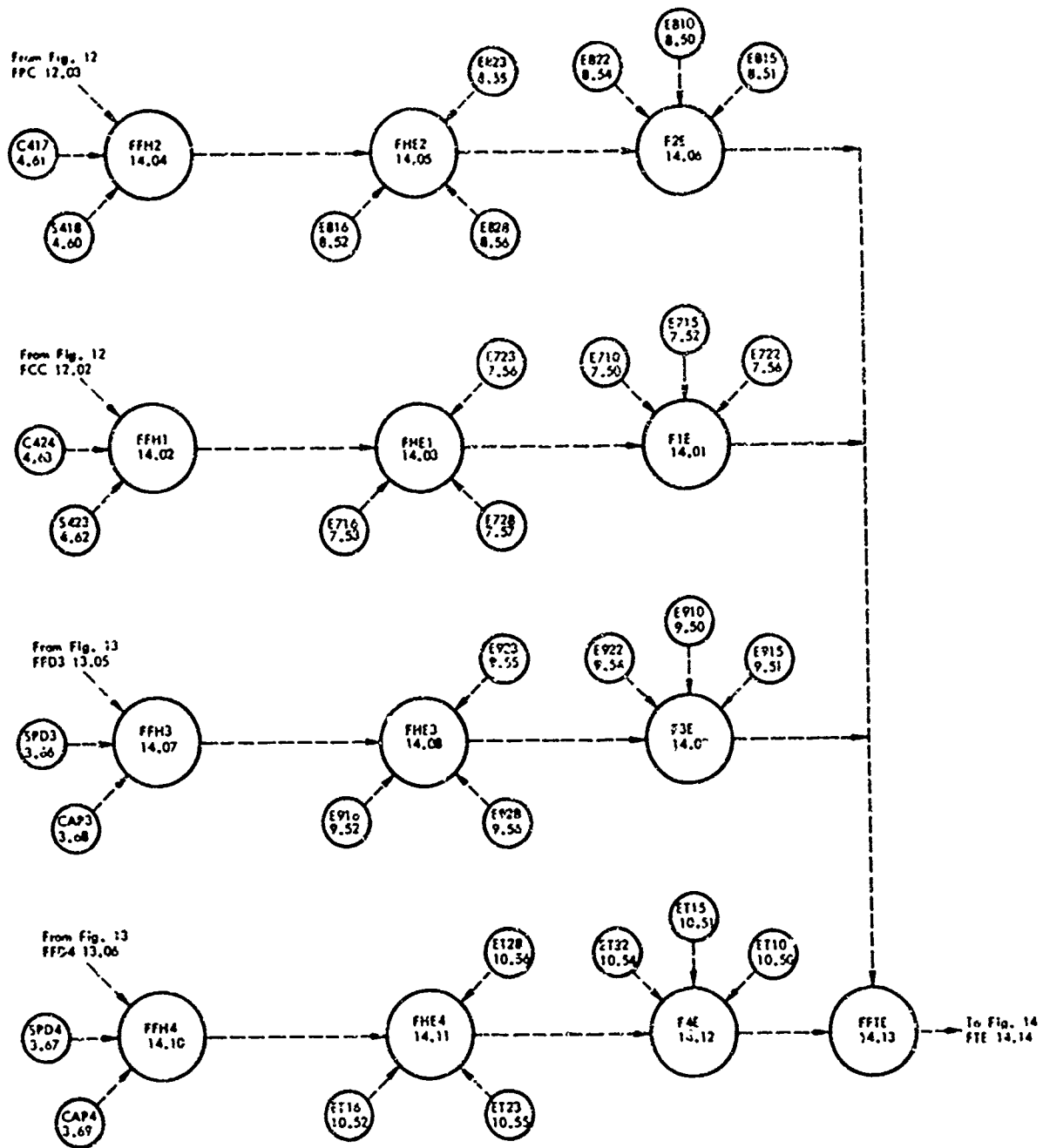


Figure 14A, Model of Forecasted Expenses

The modeling of this decision function within the system has been accomplished through the variables described in Figure 14 and 15 and their equations.

The following information on military and commercial capability is first determined from data within the system.

$$14.26 \quad FML.K = FCAP.K + FD34.K$$

FML = Total Military Capability Allocated to all classified demand

$$14.22 \quad FMC.K = FMC1.K + FMC2.K$$

FMC = Total Military plus commercial capability allocated to Cargo and PAX demand

$$12.08 \quad FTC = \text{Total Military and commercial capability allocated to all classified demand}$$

The allocation of expenses to PAX, Cargo or SAAM-Exercise is a function of the expense variable (Administrative, Terminal, or Direct) and the capabilities allocated to the particular classified demand.

Administrative expenses are allocated to each demand classification (Cargo, PAX, SAAM-Exercise) according to that portion of total capability (Commercial + Military) (FTC) allocated to that demand classification.

$$14.17 \quad F1EA.K = ADE.K(FMC1.K/FTC.K)$$

$$14.18 \quad F2EA.K = ADE.K(FMC2.K/FTC.K)$$

$$14.19 \quad F3EA.K = ADE.K(FD34.K/FTC.K)$$

Terminal expenses are allocated to the classified demand according to allocated Cargo and PAX capability. (Military + Commercial) (FMC)

$$14.20 \quad F1ET.K = TEX.K(FMC1.K/FMC.K)$$

$$14.21 \quad F2ET.K = TEX.K(FMC2.K/FMC.K)$$

Direct expenses are allocated to the classified demand according to the military capability required for each demand classification.

$$14.23 \quad F1ED.K = DTE.K(FCC.K/FML.K)$$

$$14.24 \quad F2ED.K = DTE.K(FPC.K/FML.K)$$

$$14.25 \quad F3ED.K = DTE.K(FD34.K/FML.K)$$

F1EA = Forecast Expense Rate-Cargo-Administrative (\$/week)

F2EA = Forecast Expense Rate-PAX-Administrative (\$/week)

F3EA = Forecast Expense Rate-SAAM-Exercise-Administrative (\$/week)

F1ET = Forecast Expense Rate-Cargo-Terminal (\$/week)

F2ET = Forecast Expense Rate-PAX-Terminal (\$/week)

F1ED = Forecast Expense Rate-Car Direct (\$/week)

F2ED = Forecast Expense Rate-PAX-Direct (\$/week)

F3ED = Forecast Expense Rate-SAAM-Exercise-Direct (\$/week)

The estimated expense rate for each demand function (Cargo, PAX, SAAM) is now the summation of these allocated expense rates.

14.27 $FT1E.K = FCER.K + F1EA.K + F1ET.K + F1ED.K$

14.28 $FT2E.K = FPER.K + F2EA.K + F2ET.K + F2ED.K$

14.29 $FT3E.K = F3EA.K + F3ED.K$

FT1E = Forecast Total expense rate-Cargo (\$/week)

FT2E = Forecast Total expense rate-PAX (\$/week)

FT3E = Forecast Total expense rate-SAAM & Exercise (\$/week)

A list of all variables identified in Figure 14 and their corresponding initial conditions and parameters is given in Appendix XIV.

Figure 15

The forecasted tariff is now based on recovering the forecasted expenses over the forecasting time period plus or minus an adjustment expected to correct the OBC by the end of the forecasting time period.

The forecasting time period (TIM) has been described and utilized earlier as a segment of Figure 13 and the modeling of forecasted customer demand. (See pg. 53)

The Industrial Fund plans to correct the out of balance condition (OBC) between PAX expenses and income (PD) over the time period TIM. The same is true for any out of balance condition between Cargo and SAAM expenses and income (CD). This adjustment is then subtracted from the expense rate for that classified demand.

15.04 $ADJ1.K = CD.K/TIM.K$

15.03 $ADJ2.K = PD.K/TIM.K$

ADJ1 = Adjustment due to Cargo-SAAM-Exercise income-expense difference (\$/week)

ADJ2 = Adjustment due to PAX income-expense difference (\$/week)

The expense rate for PAX movement over time period TIM is then

15.02 $FAE2.K = FT2E.K - ADJ2.K$

FAE2 = Forecasted net PAX expense rate (\$/week)

The actual forecasted demand for PAX movement is then determined by multiplying the capability allocated by the utilization factors.

$$15.11 \quad FD2.K = (FD2G.K)(FU2G) + (FD2C.K)(FU2C)$$

FD2 = Forecasted PAX Demand-actual (PAX-Miles/week)

The tariff is now determined to recover expenses (FAE2) from the customer demand (FD2).

$$15.14 \quad TR2.K = FAE2.K / FD2.K$$

TR2 = Forecasted PAX Tariff (\$/PAX-Miles/week)

The SAAM-Exercise and Cargo tariffs are determined together so that a premium charge can be allocated to SAAM-Exercise demand to cover the higher non-channel expenses associated with this demand.

First, the total Cargo-SAAM-Exercise expense rate is determined.

$$15.06 \quad SFE.K = FT1E.K + FT3E.K - ADJ1.K$$

SFE = Forecasted net expense rate for SAAM-Exercise and Cargo movement (\$/week)

The resulting expense rate (SFE) is then allocated to Cargo and SAAM-Exercise Expense based on the amount of military capability allotted to each but with SAAM-Exercise charged a 15% premium for extra costs associated with special handling.

$$15.07 \quad STR.K = FD34.K / FML.K$$

$$15.09 \quad F3AE.K = (SFE.K)(1.15)(STR.K)$$

$$15.10 \quad F1AE.K = SFE.K - F3AE.K$$

STR = Forecasted expense rate-Cargo-SAAM-Exercise (\$/week)

F3AE = Forecasted net expense rate-SAAM-Exercise (\$/week)

F1AE = Forecasted net expense rate-Cargo (\$/week)

The SAAM-Exercise forecasted tariff is now determined to recover SAAM-Exercise expenses (F3AE) from the demand for SAAM-Exercise (FD34).

$$15.13 \quad TR3.K = F3AE.K / FD34.K$$

TR3 = Forecasted SAAM-Exercise Tariff (\$/Ton-Mil.)

The actual forecasted Cargo demand is determined as follows: (See pages 13.01 and 13.02)

$$15.12 \quad FD1.K = (FD1G.K)(FU1G) + (FD1C.K)(FU1C)$$

FD1 = Forecasted Cargo Demand-Actual (Ton-Miles/week)

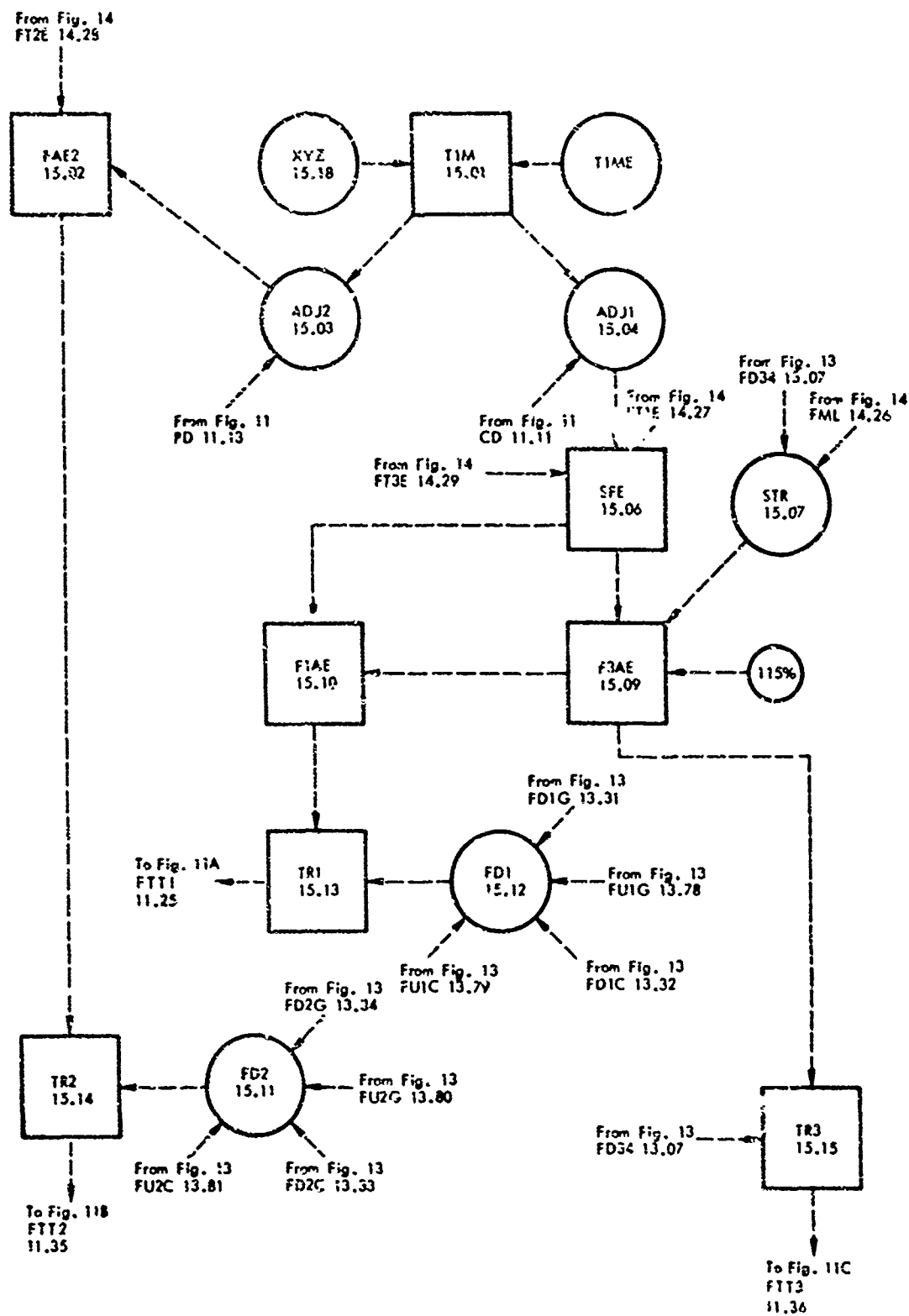


Figure 15. Model of Forecasted Tariff Calculation

The tariff is now determined to recover Cargo expenses (FLAE) from Cargo Demand (FD1).

$$15.13 \quad TR1.K = FLAE.K / FD1.K$$

TR1 = Forecasted Cargo Tariff (\$/Ton-mile)

A list of all variables identified in Figure 15 and their corresponding initial conditions and parameters is given in Appendix XV.

Input Variables

This completes the description and explanation of the basic model. The exogenous input to the system is primarily the customer demand. We have written demand equations which will allow the model to be massaged by a step input, a ramp input, a sine input, or a noise input. These equations are identified in this manner.

$$1.01 \quad D1G.K = D1GI + ISTA.K + IRPA.K + ISNA.K + INOA.K$$

$$1.02 \quad D1C.K = D1CI + ISTB.K + IRPB.K + ISNB.K + INOB.K$$

$$2.01 \quad D2G.K = D2GI + ISTC.K + IRPC.K + ISNC.K + INOC.K$$

$$2.02 \quad D2C.K = D2CI + ISTD.K + IRPD.K + ISND.K + INOD.K$$

$$3.01 \quad D3S.K = D3SI + ISTE.K + IRPE.K + ISNE.K + INOE.K$$

$$3.02 \quad D4E.K = D4EI + ISTF.K + IRPF.K + ISNF.K + INOF.K$$

D1GI = Initial Value-Customer Cargo Demand-Outgoing

D1CI = Initial Value-Customer Cargo Demand-Incoming

D2GI = Initial Value-Customer PAX Demand-Outgoing

D2CI = Initial Value-Customer PAX Demand-Incoming

D3SI = Initial Value-Customer SAAM Demand

D4EI = Initial Value-Customer Exercise Demand

The step input is provided by the following variables.

$$1.26 \quad ISTA.K = STEP(XA, 5)$$

$$1.27 \quad ISTB.K = STEP(XB, 5)$$

$$2.04 \quad ISTC.K = STEP(XC, 5)$$

$$2.05 \quad ISTD.K = STEP(XD, 5)$$

$$3.03 \quad ISTE.K = STEP(XE, 5)$$

$$3.04 \quad ISTF.K = STEP(XF, 5)$$

The ramp input is provided by the following variables:

- 1.28 $IRPA.K = RAMP(YA, 5)$
- 1.29 $IRPB.K = RAMP(YB, 5)$
- 2.27 $IRPC.K = RAMP(YC, 5)$
- 2.28 $IRPD.K = RAMP(YD, 5)$
- 3.21 $IRPE.K = RAMP(YE, 5)$
- 3.22 $IRPF.K = RAMP(YF, 5)$

The sine input is provided by the following equations:

- 1.30 $ISNA.K = STEP(SNA.K, 5)$
- 1.31 $SNA.K = X1G * SIN((6.3 * TIME.K)/PER1)$
- 1.32 $ISNB.K = STEP(SNB.K, 5)$
- 1.33 $SNB.K = X1C * SIN((6.3 * TIME.K)/PER1)$
- 2.29 $ISNC.K = STEP(SNC.K, 5)$
- 2.30 $SNC.K = X2G * SIN((6.3 * TIME.K)/PER2)$
- 2.31 $ISND.K = STEP(SND.K, 5)$
- 2.32 $SND.K = X2C * SIN((6.3 * TIME.K)/PER2)$
- 3.23 $ISNE.K = STEP(SNE.K, 5)$
- 3.24 $SNE.K = X3X * SIN((6.3 * TIME.K)/PER3)$
- 3.25 $ISNF.K = STEP(SNF.K, 5)$
- 3.26 $SNF.K = X4X * SIN((6.3 * TIME.K)/PER4)$

The noise input is provided by the following equations:

- 1.34 $INOA.K = STEP(NOA.K, 5)$
- 1.35 $NOA.K = IX1 * NORMRN(NAEM, STV1)$
- 1.36 $INOB.K = STEP(NOB.K, 5)$
- 1.37 $NOB.K = IX2 * NORMRN(NAEM, STV2)$
- 2.33 $INOC.K = STEP(NOC.K, 5)$
- 2.34 $NOC.K = IX3 * NORMRN(NAEM, STV3)$
- 2.35 $INOD.K = STEP(NOD.K, 5)$

- 2.36 $NOD.K = IX4 * NORMRN (NAEM, STV4)$
- 3.27 $INOE.K = STEP (NOF.K, 5)$
- 3.28 $NOE.K = IX5 * NORMRN (NAEM, STV5)$
- 3.29 $INOF.K = STEP (NOF.K, 5)$
- 3.30 $NOF.K = IX6 * NORMRN (NAEM, STV6)$

Initial Values

Each variable in the model has been identified in terms of other variables and constants. The variables must all be given an initial value before the model will be operational. The Dynamo Compiler requires that the value of all level equations be identified and the value for the majority of the auxiliary and rate equations will be computed by the Compiler. All variables and their initial equations are identified by figure number and a listing given in the Appendices. All initial values have been appropriately selected so the model will be in steady state. Any dynamics in the model caused by a change in a variable or due to a change in input can then be attributed to that specific change and the structure of the system as concerned.

Output Information

The Dynamo Compiler enables us to request information regarding the value of any variable through the length of the model run.

The specification card for each run looks something like this:

SPEC $DT = 0.1/LENGTH = 100/PRTPER = 2/PLTPER = 3$

This indicates that each variable will be computed every 0.1 week in our model as the basic time period has been specified as a week. The length of the simulation run will be 100 weeks and we have requested it to print information on the value of specified variables every 2 weeks and plot specified variables every 3 weeks. The information on the Spec Card can be changed to provide the output information necessary for an appropriate analysis.

For the basic model we have requested information on those variables which we believe to be most significant in our analysis. This information is listed in Appendix XVI.

Summary

This report has presented a graphical description of the basic model of the ASIF in Figures 1 through 15. A verbal description of the model with an explanation of the reason for selecting each variable and the rationale for each variable relationship has accompanied each figure. The appendices finally list all the variables, their initial values, and the input variables which may be used for model testing. The output information to be requested has also been identified.

The model has been tested for logic errors and is found to be logically correct. At this time the Analyst feels this model is a reasonable representation of the ASIF system and will replicate the dynamics of the ASIF system created by various input data.

APPENDICES

I THROUGH XVI

APPENDIX I

NOTE	FIG.01	CARGO MODEL
A	D1G.K=D1GI+ISTA.K+IRPA.K+ISNA.K+INOA.K	1.01
A	D1C.K=D1CI+ISTB.K+IRPB.K+ISNB.K+INOB.K	1.02
R	SIG.KL=SIGT.K	1.03
R	SIC.KL=SICT.K	1.04
6R	ISIG.KL=DIIG.K	1.05
6R	ISIC.KL=DIIC.K	1.06
1L	INIG.K=INIG.J+(DT){ISIG.JK-SIG.JK}	1.07
1L	INIC.K=INIC.J+(DT){ISIC.JK-SIC.JK}	1.08
44A	SIGT.K={INIG.K}(1/D17)	1.09
44A	SICT.K={INIC.K}(1/D18)	1.10
2CA	CIG.K=SIGT.K/UIG	1.11
20A	CIC.K=SICT.K/UIC	1.12
12A	TC1.K=(2){MX1.K}	1.13
56A	MX1.K=MAX(CIG.K,CIC.K)	1.14
R	CB1.KL=CLIP(TCB1.K,O,TCB1.K,O)	1.15
7A	TCB1.K=TC1.K-ACC.K	1.16
3L	SDIG.K=SDIG.J+(DT){1/D120}{ISIG.JK-SDIG.J}	1.17
3L	SDIG.K=SDIG.J+(DT){1/D119}{ISIG.JK-SDIG.J}	1.18
12A	ACC.K=(CPD)(CCA.K)	1.19
6R	RIG.KL=ISIG.JK	1.20
A	RTIG.K={1/DT}{ISIG.JK-RIG.JK}	1.21
3L	SRIG.K=SRIG.J+(DT){1/SDL}{RTIG.J-SRIG.J}	1.22
6R	RIC.KL=ISIC.JK	1.23
A	RTIC.K={1/DT}{ISIC.JK-RIC.JK}	1.24
3L	SRIC.K=SRIC.J+(DT){1/SDL}{RTIC.J-SRIC.J}	1.25
A	ISTA.K=STEP(XA,5)	1.26
A	ISTB.K=STEP(XB,5)	1.27
A	IRPA.K=RAMP(YA,5)	1.28
A	IRPB.K=RAMP(YB,5)	1.29
A	ISNA.K=STEP(SNA.K,5)	1.30
A	SNA.K=XIG*SIN((6.3*TIME.K)/PER1)	1.31
A	ISNB.K=STEP(SNB.K,5)	1.32
A	SNB.K=XIC*SIN((6.3*TIME.K)/PER1)	1.33
A	INCA.K=STEP(NGA.K,5)	1.34

```

A NOA.K=IX1*NORMRN(NAEM,STV1)
A INOE.K=STEP(NOB.K,5)
A NOB.K=IX2*NORMRN(NAEN,STV2)
      INITIAL CONDITIONS AND PARAMETERS

6N   DIC=DICI
6N   DIG=DIGI
6N   INIG=INIGI
6N   INIC=INICI
      N SDIC=SDICI
      N SDIG=SDIGI
      D120=24
      DIGI=4000000
      C   XA=0
      C   DICI=40000000
      C   X8=0
      C   D17=0.3
      C   D18=0.3
      C   INIGI=12E6
      C   INICI=12E6
      C   UIG=0.81
      C   UIC=0.81
      C   D119=24
      C   CPD=0.907
      C   SGL=20
      C   YA=C
      C   YB=C
      C   NAEM=0
      C   IX1=0
      C   IX2=C
      C   STV1=0
      C   STV2=0
      C   XIG=0
      C   XIC=0
      C   PER1=24
      C   SDICI=40E6
      C   SDIGI=40E6
      N   SRIG=SRIGI

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1.35
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1.84
1.85
1.86

C SRIGI=C
N SRIC=SRICI
C SRICI=O

APPENDIX II

NOTE	FIG. C2	PAX MODEL	
A	D2G.K=D2GI+ISTC.K+IRPC.K+ISNC.K+INOC.K		2.01
A	D2C.K=D2CI+ISIC.K+IRPD.K+ISND.K+INOD.K		2.02
A	ISIC.K=STEP(XC,5)		2.03
A	ISID.K=STEP(XD,5)		2.04
6R	IS2G.KL=D2G.K		2.05
6R	IS2C.KL=D2C.K		2.06
1L	IN2G.K=IN2G.J+(DT)*(IS2G.JK-S2G.JK)		2.07
1L	IN2C.K=IN2C.J+(DT)*(IS2C.JK-S2C.JK)		2.08
7A	MPR.K=TC2.K-CB2.K		2.09
A	RT2C.K=(1/DT)*(IS2C.JK-R2C.JK)		2.10
3L	SR2C.K=SR2C.J+(DT)*(1/SDP)*(RT2C.J-SR2C.J)		2.11
44A	S2GT.K=(IN2G.K)*(1/D27)		2.12
6R	S2G.KL=S2GT.K		2.13
44A	S2CT.K=(IN2C.K)*(1/D28)		2.14
6R	S2C.KL=S2CT.K		2.15
20A	C2G.K=S2GT.K/U2G		2.16
20A	C2C.K=S2CT.K/U2C		2.17
56A	MX2.K=MAX(C2G.K,C2C.K)		2.18
12A	TC2.K={2}(MX2.K)		2.19
12A	CB2.K={TC2.K}(FCB)		2.20
3L	SD2G.K=SD2G.J+(DT)*(1/D219)*(IS2G.JK-SD2G.J)		2.21
3L	SD2C.K=SD2C.J+(DT)*(1/D220)*(IS2C.JK-SD2C.J)		2.22
6R	R2G.KL=IS2G.JK		2.23
A	RT2G.K=(1/DT)*(IS2G.JK-R2G.JK)		2.24
3L	SR2G.K=SR2G.J+(DT)*(1/SDP)*(RT2G.J-SR2G.J)		2.25
6R	R2C.KL=IS2C.JK		2.26
A	IRPC.K=RAMP(YC,5)		2.27
A	IRPD.K=RAMP(YD,5)		2.28
A	ISNC.K=STEP(SNC.K,5)		2.29
A	SNC.K=X2G*SIN((6.3*TIME.K)/PER2)		2.30
A	ISND.K=STEP(SND.K,5)		2.31
A	SND.K=X2C*SIN((6.3*TIME.K)/PER2)		2.32
A	INOC.K=STEP(NOC.K,5)		2.33
A	NOC.K=IX3*NORMRN(NAEM,STV3)		2.34

```

A INUD,K=STEP(NOD,K,5)
A NOD,K=(IX4)*NODHRN(NAE,K,STV4)
      INITIAL CONCILL,V3 AND PARAMETERS

6N D2G=D2G1
6N D2C=D2C1
6N IN2G=IN2G1
6N IN2C=IN2C1
      N SD2C=SD2C1
      N SD2G=SD2G1
C D2G1=10E7
C XC=C
C D2C1=10E7
C XD=C
C U27=C.2
C D28=C.2
C IN2G1=20E6
C IN2C1=20E6
C U2G=C.91
C U2C=C.81
C D219=24
C D220=24
C YC=C
C YD=C
C IX3=0
C IX4=0
C STV3=0
C STV4=0
C X2G=0
C X2C=0
C PER2=26
C SD2C1=10E6
C SD2G1=10E6
      N SR2G=SR2G1
      C SR2C1=0
      N SR2C=SR2C1
      C SR2C1=0
      C FCB=0.92
2.35
2.36
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2.84

C SDP=2C

APPENDIX III

NOTE	FIG. C3	SAAM & EXERCISE MODEL	
A	D3S.K=D3SI+ISTE.K+IRPE.K+ISNE.K+INOI.K		3.01
A	D4E.K=D4EI+ISIF.K+IRPF.K+ISNF.K+INOF.K		3.02
A	ISTE.K=STEP(XE,5)		3.03
A	ISIF.K=STEP(XF,5)		3.04
6R	IS3.KL=D3S.K		3.05
6R	IS4.KL=D4E.K		3.06
1L	IN3.K=IN3.J+(DT)(IS3.JK-S3S.JK)		3.07
1L	IN4.K=IN4.J+(DT)(IS4.JK-S4E.JK)		3.08
39R	S3S.KL=DELAY3(IS3.JK,D34)		3.09
39R	S4E.KL=DELAY3(IS4.JK,D316)		3.10
3L	SD3.K=SD3.J+(DT)(1/D312)(IS3.JK-SD3.J)		3.11
3L	SD4.K=SD4.J+(DT)(1/D38)(IS4.JK-SD4.J)		3.12
42A	PH3.K=S3S.JK/((SPD3)(CAP3))		3.13
42A	PH4.K=S4E.JK/((SPD4)(CAP3))		3.14
6R	R3.KL=IS3.JK		3.15
6R	R4.KL=IS4.JK		3.16
A	RT3.K=(1/DT)(IS3.JK-R3.JK)		3.17
A	RT4.K=(1/DT)(IS4.JK-R4.JK)		3.18
3L	SR3.K=SR3.J+(DT)(1/SDS)(RT3.J-SR3.J)		3.19
3L	SR4.K=SR4.J+(DT)(1/SDS)(RT4.J-SR4.J)		3.20
A	IRPE.K=RAMP(YE,5)		3.21
A	IRPF.K=RAMP(YF,5)		3.22
A	ISNE.K=STEP(SNE.K,5)		3.23
A	SNE.K=X3X#SIN((6.3#TIME.K)/PER3)		3.24
A	ISNF.K=STEP(SNF.K,5)		3.25
A	SNF.K=X4X#SIN((6.3#TIME.K)/PER4)		3.26
A	INOE.K=STEP(NOE.K,5)		3.27
A	NOE.K=IX5#NORMRN(NAEM,STV5)		3.28
A	INOF.K=STEP(NOF.K,5)		3.29
A	NOF.K=IX6#NORMRN(NAEM,STV6)		3.30
INITIAL CONDITIONS AND PARAMETERS			
6N	D3S=D3SI		3.50
6N	D4E=D4EI		3.51
6N	IN3=IN3I		3.52

6N	IN4=IN4I	3.53
6N	SD3I=D3SI	3.54
6N	SD4I=D4EI	3.55
C	D3SI=24000000	3.56
C	XE=0	3.57
C	D4EI=685000	3.58
C	XF=0	3.59
C	IN3I=12000000	3.60
C	IN4I=2055000	3.61
C	D34=0.5	3.62
C	D316=3	3.63
C	D312=24	3.64
C	D38=24	3.65
C	SPD3=462	3.66
C	SPD4=462	3.67
C	CAP3=24.6	3.68
C	CAP4=24.6	3.69
C	SDS=20	3.70
C	IX5=0	3.71
C	IX6=0	3.72
C	STV5=C	3.73
C	STV6=0	3.74
C	X4X=0	3.75
C	PER4=26	3.76
C	X3X=0	3.77
C	PER3=26	3.78
C	N SR3=SR3I	3.79
C	C SR3I=0	3.80
C	N SR4=SR4I	3.81
C	C SR4I=0	3.82
C	N SD3=SD3I	3.83
C	N SD4=SD4I	3.84
C	YE=0	3.85
C	YF=0	3.86

APPENDIX IV

FIG. 34 AVAILABLE & DISKINUTED MILITARY CAPACITY

NOTE	FIG. 34 AVAILABLE & DISKINUTED MILITARY CAPACITY	
12A	TAF.K=(TAF.K)(UTAF)	4.01
47A	AF.K=RAMP(RMP,5)	4.02
7A	TAF.K=TAFI+AFI.K	4.03
13A	ICAP.K=(T+HC.K)(SPD)(CAP)	4.04
6R	TRNR.KL=TRN.K	4.05
9A	ACAP.K=TCAP.K-S5S.JK-S4E.JK-TRN.K	4.06
3L	SMT.K=SMT.J+(DT)(1/D428)(TRNR.JK-SMT.J)	4.07
7A	CCA.K=ACAP.K-PCA.K	4.08
12A	FCA.K=(PPN)(PMC.N)	4.09
42A	FH1.K=CCA.K/((S423)(C424))	4.10
12A	PMC.K=(MPR.K)(PAX)	4.11
42A	FH1.K=PCA.K/((S416)(C417))	4.12
12A	TRN.K={TRN1}(MLTD.K)	4.13
DL	MLTD.K=MLTD.J+(DT)(1/DMA)(MLT.J-MLTD.J)	4.14
L	SX1.K=SX1.J+(DT)(1/DXC)(EX1C.JK-SX1.J)	4.15
L	SX2.K=SX2.J+(DT)(1/DXP)(ER2C.JK-SX2.J)	4.16
A	SXX.K=SX1.K+SX2.K	4.17
A	RTD.K=SXX.K/CEL	4.18
A	MLT.K=TABLE(TAB,RTD.K,0,1.5,0.1)	4.19
	INITIAL CONDITIONS AND PARAMETERS	
N	SX2=SX2I	4.46
N	SX1=SX1I	4.47
N	SMT=TRNI	4.48
N	MLTD=MLTDI	4.49
6N	TAF=TAFI	4.50
6N	TRN=TRNI	4.51
C	UTAF=5C	4.52
C	TAFI=176	4.53
C	RMP=0	4.54
C	SPD=462	4.55
C	CAP=24.6	4.56
C	D428=52	4.57
C	PPD=1.069	4.58
C	PAX=C.235	4.59

FIGURE 5 INDUSTRIAL FUND MANIFEST MODEL

0	0513=3
0	0516=0.3
0	0519=2
0	0523=3
0	0526=0.3
0	0529=2
0	0533=2
0	0543=2
0	0546=0.3
0	0549=2
0	0549=2

APPENDIX VI

FIG. 66 CASH FLOW MODEL	
NOTE	
12K	BR1.KL=(TRF1.K)(MPI.JK)
12K	BR2.KL=(TRF2.K)(MP2.JK)
12K	BR3.KL=(TRF3.K)(MP3.JK)
12K	BR4.KL=(TRF3.K)(NP4.JK)
39R	CR1.KL=DELAY3(BR1.JK,D614)
39R	CR2.KL=DELAY3(BR2.JK,D624)
39R	CR3.KL=DELAY3(BR3.JK,D634)
39R	CR4.KL=DELAY3(BR4.JK,D644)
21	CSH.K=CSH.J+(DT)(CR1.JK+CR2.JK+CR3.JK+CR4.JK-COR.JK+O)
20R	NCR.KL=CSHT.K/DT
7A	CSH1.K=CSH.K-5.0E9
1A	PDA.K=PDA.J+(DT)(EPR.J-COR.JK)
6N	PDA=PDAI
54R	COR.KI=MIN(DCR.K,NCR.JI)
20A	DCR.K=PDA.K/DT
9A	EPR.K=ER1.K+ER2.K+ER3.K+ER4.K
10A	ER1.K=PR1A.JK+PR1D.JK+PR1P.JK+PR1C.JK+O
10A	ER2.K=PR2A.JK+PR2B.JK+PR2D.JK+PR2P.JK+PR2C.JK+O
9A	ER3.K=PR3A.JK+PR3B.JK+PR3D.JK+PR3P.JK
9A	ER4.K=PR4A.JK+PR4B.JK+PR4D.JK+PR4P.JK
INITIAL CONDITIONS AND PARAMETERS	
6N	TRF1=TRF11
N	TRF2=TRF21
N	TRF3=TRF31
N	SSEI=SSEI1
N	SH=CSH1
C	TRF11=0.095
C	TRF21=0.03
C	TRF31=0.124
C	SSEI1=2.078E6
C	CSH1=25.E6
C	PDAI=0
C	D614=2
C	D624=2

6.6.3
0.64

C 0034=1
; 0044=4

APPENDIX VII

NOTE		FIG. 07 CARGO EXPENSE MODEL	
R		ER10.KL={719+FH1.K#E716	7.01
R		ER10.KL=(1)(L722)+(E723)(FH1.K)	7.02
12R		ER10.KL=(L728)(FH1.K)	7.03
6R		ER1A.KL=E710	7.04
39R		PR1A.KL=DELAY3(ER1A.JK,D713)	7.05
39R		PR1B.KL=DELAY3(ER1B.JK,D720)	7.06
39R		PR1D.KL=DELAY3(ER1D.JK,D720)	7.07
39R		PR1P.KL=DELAY3(ER1P.JK,D731)	7.08
12R		ER1C.KL=(E733)(CB1.JK)	7.09
39R		PR1C.KL=DELAY3(ER1C.JK,D736)	7.10
INITIAL CONDITIONS AND PARAMETERS			
C		E710=134500	7.50
C		E715=239.4E3	7.52
C		E716=126	7.53
C		E722=111.8E3	7.55
C		E723=53	7.56
C		E728=244	7.57
C		E733=0.1770	7.58
C		D713=4	7.59
C		D720=4	7.60
C		D726=4	7.61
C		D731=4	7.62
C		D736=1	7.63

APPENDIX VIII

FIG. 08 PAX EXPENSE MODEL

NOTE	ER2A.KL=E810	8.01
6R	PR2A.KL=DELAY3(ER2A.JK,D813)	8.02
39R	ER2B.KL=E815+FH2.K+E816	8.03
R	PR2B.KL=DELAY3(ER2B.JK,D820)	8.04
39R	FR2D.KL=(1)(E822)+(E823)(FH2.K)	8.05
R	PR2D.KL=DELAY3(ER2D.JK,D826)	8.06
39R	ER2P.KL=(E828)(FH2.K)	8.07
12R	PR2P.KL=DELAY3(ER2P.JK,D831)	8.08
39R	ER2C.KL=(E833)(CB2.K)	8.09
12R	PR2C.KL=DELAY3(ER2C.JK,D836)	8.10
39R		
	INITIAL CONDITIONS AND PARAMETERS	
C	E810=10200	8.50
C	E815=18125	8.51
C	E816=125	8.52
C	E822=8451	8.54
C	E823=53	8.55
C	E828=244	8.56
C	E833=0.0252	8.57
C	D813=4	8.58
C	D820=4	8.59
C	D826=4	8.60
C	D831=4	8.61
C	D836=1	8.62

APPENDIX IX

NOTE		FIG. 09 SAAM EXPENSE MODEL	
39K	R	PK=A.KL=DELAY3(ER3A.JK,D915)	9.01
	R	ER3B.KL=L915+FH3.K#E916	9.02
39R	R	PR3J.KL=DELAY3(ER3B.JK,D920)	9.03
	R	ER3D.KL=(1)(E922)+(E923)(FH3.K)	9.04
39R	R	PR3D.KL=DELAY3(ER3D.JK,D926)	9.05
12R	R	ER3P.KL=(E928)(FH3.K)	9.06
39R	R	PR3P.KL=DELAY3(ER3P.JK,D931)	9.07
6R	R	ER3A.KL=E910	9.08
INITIAL CONDITIONS AND PARAMETERS			
C		E910=57100	9.50
C		E915=101.6E3	9.51
C		E916=126	9.52
C		E922=47.4E3	9.54
C		E923=53	9.55
C		E928=244	9.56
C		D913=4	9.57
C		D920=4	9.58
C		D926=4	9.59
C		D931=4	9.60

APPENDIX X

FIG. 10
EXERCISE EXPENSE MODEL

NOTE	FIG. 1C	EXERCISE	EXPENSE	MODEL
R	ER4B.KL=ET15+FH4.K#ET16			1C.C1
6R	ER4A.KL=ET1C			1C.C2
39R	PR4A.KL=DELAY3(ER4A.JK,DT13)			10.C3
39R	PR4B.KL=DE'AY3(ER4B.JK,DT20)			10.C4
R	ER4D.KL=(1)(ET22)+(ET23)(FH4.K)			10.C5
39R	PR4D.KL=DELAY3(ER4D.JK,DT26)			10.C6
12R	ER4P.KL=(ET28)(FH4.K)			10.C7
39R	PR4P.KL=DELAY3(ER4P.JK,DT31)			10.C8
	INITIAL CONDITIONS AND PARAMETERS			
C	ET1C=200C			10.50
C	ET15=3625			10.51
C	ET16=126			10.52
C	ET22=1701			10.54
C	ET23=53			10.55
C	ET28=244			10.56
C	DT13=1			10.57
C	DT20=1			10.58
C	DT26=1			10.59
C	DT31=1			10.60

APPENDIX XI

FIG. 11 TARIFF DECISION MODEL

NOTE	TCE.K=ICE.J+DT*(ER1A.JK+ER1B.JK+ER1D.JK+ER1P.JK+ER1C.JK)	11.01
L	TPE.K=TPE.J+DT*(ER2A.JK+ER2B.JK+ER2D.JK+ER2P.JK+ER2C.JK)	11.03
52L	TSE.K=TSE.J+DT*(ER3A.JK+ER3B.JK+ER3D.JK+ER3P.JK)	11.04
9A	TE.K=TCE.K+TPE.K+TSE.K+TEE.K	11.05
L	TEE.K=TEE.J+DT*(ER4A.JK+ER4B.JK+ER4D.JK+ER4P.JK)	11.06
1L	TPI.K=TPI.J+DT*(MI2.J+C)	11.07
52L	TI.K=TI.J+DT*(MI1.J+MI2.J+MI3.J+MI4.J)	11.08
A	TECI.K=TI.K-TPI.K	11.09
A	TCEE.K=TE.K-TPE.K	11.10
A	CD.K=TECI.K-TCEE.K	11.11
A	PD.K=1PI.K-TPE.K	11.13
12A	MI1.K=(MR1.JK)(TRF1.K)	11.14
12A	MI2.K=(MR2.JK)(TRF2.K)	11.15
12A	MI3.K=(MR3.JK)(TRF3.K)	11.16
12A	MI4.K=(MR4.JK)(TRF3.K)	11.17
3L	SCI.K=SCI.J+DT*(1/DE15)(MI1.J-SCI.J)	11.18
3L	SPI.K=SP.DT*(1/DE16)(MI2.J-SPI.J)	11.19
4L	SSEI.K=SCI.K+J+DT*(MI3.J+MI4.J-SSEI.J+O+O+C)	11.20
A	SCEI.K=SCI.K+SSEI.K	11.21
7K	TTR1.KL=TRF1.K	11.22
7R	TTR2.KL=TRF2.K	11.23
7R	TTR3.KL=TRF3.K	11.24
7A	TT1.K=TTR1.K	11.25
7A	TY2.K=TTR2.K	11.26
7A	TT3.K=TTR3.K	11.27
A	RC.K=(100)(CDX.K)/SCEI.K	11.28
44A	RP.K=(100)(PDX.K)/SPI.K	11.29
A	RCX.K=(-1)(CD.K)	11.30
A	RPX.K=(-1)(PD.K)	11.31
A	CLX.K=CLIP(CD.K,RCX.K,CD.K,C)	11.32
A	PDX.K=CLIP(PD.K,RPX.K,PD.K,O)	11.33
51A	FTT1.K=CLIP(TR1.K,TT1.K,RC.K,DRC)	11.34
51A	FTT2.K=CLIP(TR2.K,TT2.K,RP.K,DRC)	11.35
A	FTT3.K=CLIP(TR3.K,TT3.K,RC.K,DRC)	11.36

51A	STI1.K=CLIP(FTT1.K,TT1.K,TM1.K,DIMD)	11.42
51A	STI2.K=CLIP(FTT2.K,TT2.K,TM2.K,DIMD)	11.43
51A	STI3.K=CLIP(FTT3.K,TT3.K,TM3.K,DIMD)	11.44
A	DF1.K=STI1.K-TT1.K	11.45
A	DF2.K=STI2.K-TT2.K	11.46
A	DF3.K=STI3.K-TT3.K	11.47
A	DF4.K=(-1)(DF1.K)	11.48
A	DF5.K=(-1)(DF2.K)	11.49
A	DF6.K=(-1)(DF3.K)	11.50
A	DF7.K=MAX(DF1.K,DF4.K)	11.51
A	DF8.K=MAX(DF2.K,DF5.K)	11.52
A	DF9.K=MAX(DF3.K,DF6.K)	11.53
A	TCH1.K=(1/TT1.K)(DF7.K)	11.54
A	TCH2.K=(1/TT2.K)(DF8.K)	11.55
A	TCH3.K=(1/TT3.K)(DF9.K)	11.56
51A	DTM1.K=CLIP(TIME.K,PTM1.K,TCH1.K,DCH)	11.57
51A	DTM2.K=CLIP(TIME.K,PTM2.K,TCH2.K,DCH)	11.58
51A	DTM3.K=CLIP(TIME.K,PTM3.K,TCH3.K,DCH)	11.59
7R	DET1.KL=DTM1.K	11.60
7R	DET2.KL=DTM2.K	11.61
7R	DET3.KL=DTM3.K	11.62
A	PTM1.K=DET1.K	11.63
A	PTM2.K=DET2.K	11.64
A	PTM3.K=DET3.K	11.65
7A	TM1.K=TIME.K-PTM1.K	11.66
7A	TM2.K=TIME.K-PTM2.K	11.67
7A	TM3.K=TIME.K-PTM3.K	11.68
51A	TRF1.K=CLIP(STI1.K,TT1.K,TCH1.K,DCH)	11.69
51A	TRF2.K=CLIP(STI2.K,TT2.K,TCH2.K,DCH)	11.70
51A	TRF3.K=CLIP(STI3.K,TT3.K,TCH3.K,DCH)	11.71
INITIAL CONDITIONS AND PARAMETERS		
6N	TCE=ICEI	11.100
6N	TPE=1PII	11.101
6N	TSE=TSFI	11.102
6N	TEE=TEFI	11.104
6N	TR=TEI	11.105
6N	TPI=1PII	11.107

6N	TI=TI1	11.108
6N	SCI=SCI1	11.109
6N	SPI=SPI1	11.110
N	TI1=TI11	11.112
N	TI2=TI21	11.113
N	TI3=TI31	11.114
N	TMD1=TMD11	11.115
N	TMD2=TMD21	11.116
N	TMD3=TMD31	11.117
N	TCH1=TCH11	11.118
N	TCH2=TCH21	11.119
N	TCH3=TCH31	11.120
N	PTM1=PTM11	11.121
N	PTM2=PTM21	11.122
N	PTM3=PTM31	11.123
N	DTM1=DTM11	11.124
N	DTM2=DTM21	11.125
N	DTM3=DTM31	11.126
C	TCE1=0	11.127
C	TPE1=0	11.128
C	TSE1=0	11.129
C	TEE1=0	11.130
C	TEI=0	11.131
C	TPI1=0	11.132
C	TI1=0	11.133
C	SCI1=12E6	11.134
C	SPI1=5E6	11.135
C	DE15=8	11.136
C	DE16=8	11.137
C	DE17=8	11.138
C	DRC=100	11.139
C	DRP=100	11.140
C	DTMD=12	11.141
C	DCH=0.01	11.142
C	TI11=0.095	11.143
C	TI21=0.03	11.144
C	TI31=0.128	11.145

11.152
11.153
11.154
11.155
11.156
11.157
11.158
11.159
11.160
11.161
11.162
11.163

TMD1I=0
TMD2I=0
TMD3I=0
TCH1I=0
TCH2I=0
TCH3I=0
PTM1I=0
PTM2I=0
PTM3I=0
DTM1I=0
DTM2I=0
DTM3I=0

C
C
C
C
C
C
C
C
C
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C
C

APPENDIX XII

FIG. 12 MILITARY CAPABILITY MODEL

NOTE

8A 5CAP.K=1CAP.K-SMT.K+FD34.K
 7A FCC.K=FCCAP.K-FPC.K
 12A FPC.K=(PPD)(FPR.K)
 A F1A.K=(FCC.K)(CPD)
 7A F2A.K=FD2X.K-FCB1.K
 7A FMC1.K=FCC.K+FCB1.K
 7A FMC2.K=FPC.K+F2R.K
 8A FFC.K=FMC1.K+FMC2.K+FD34.K
 A FPR.K=F2A.K/FPAX

12.C1
 12.C2
 12.C3
 12.C4
 12.C5
 12.C6
 12.C7
 12.C8
 12.C9

APPENDIX XII

FIG. 12 MILITARY CAPABILITY MODEL

NOTE	FCAP.K=ICAP.K-SM1.K-FD34.K	12.C1
8A	FCC.K=FCAP.K-FPC.K	12.C2
7A	FPC.K=(PPD)(FPR.K)	12.C3
12A	F1A.K=(FCC.K)(CPD)	12.C4
A	F2A.K=FD2X.K-FCB2.K	12.C5
7A	FMC1.K=FCC.K+FCR1.K	12.C6
7A	FMC2.K=FPC.K+F2R.K	12.C7
8A	FTC.K=FMC1.K+FMC2.K+FD34.K	12.C8
A	FPR.K=F2A.K/FPAX	12.C9

APPENDIX XIII

NOTE	FIL. 13 DEMAND FORECASTING MODEL	
A	FFD1G.K=(1/FU1G)(SD1G.K+G1G.K)	13.01
A	FFD2G.K=(1/FU2G)(SD2G.K+G2G.K)	13.02
A	FFD1C.K=(1/FU1C)(SD1C.K+G1C.K)	13.03
A	FFD2C.K=(1/FU2C)(SD2C.K+G2C.K)	13.04
A	FFD3.K=SD3.K+G3.K	13.05
A	FFD4.K=SD4.K+G4.K	13.06
7A	FD34.K=FD3.K+FD4.K	13.07
56A	FMX1.K=MAX(FD1G.K,FD1C.K)	13.08
12A	FD1X.K=(2)(FMX1.K)	13.09
56A	FMX2.K=MAX(FD2G.K,FD2C.K)	13.10
12A	FD2X.K=(2)(FMX2.K)	13.11
20A	F2R.K=FCB2.K/FPAX	13.12
7A	FTB1.K=FD1X.K-F1A.K	13.13
A	FCB1.K=CLIP(FTB1.K,0,FTB1.K,C)	13.14
12A	FCB2.K=(CBY)(FD2X.K)	13.15
7A	FTCB.K=FCB1.K+F2R.K	13.16
12A	FPER.K=(CC17)(FCB2.K)	13.17
12A	FCER.K=(CC18)(FCB1.K)	13.18
44A	G1G.K=(SR1G.K)(TIM.K)/2	13.19
44A	G1C.K=(SR1C.K)(TIM.K)/2	13.20
44A	G2G.K=(SR2G.K)(TIM.K)/2	13.21
44A	G2C.K=(SR2C.K)(TIM.K)/2	13.22
44A	G3.K=(SR3.K)(TIM.K)/2	13.23
44A	G4.K=(SR4.K)(TIM.K)/2	13.24
A	SF1G.K=FFD1G.K*NORMRN(MEAN,STDV2)	13.25
A	SF1C.K=FFD1C.K*NORMRN(MEAN,STDV3)	13.26
A	SF2G.K=FFD2G.K*NORMRN(MEAN,STDV4)	13.27
A	SF2C.K=FFD2C.K*NORMRN(MEAN,STDV5)	13.28
A	SF3.K=FFD3.K*NORMRN(MEAN,STDV6)	13.29
A	SF4.K=FFD4.K*NORMRN(MEAN,STDV7)	13.30
A	FD1G.K=SMOOTH(SF1G.K,DEF2)	13.31
A	FD1C.K=SMOOTH(SF1C.K,DEF3)	13.32
A	FD2C.K=SMOOTH(SF2C.K,DEF5)	13.33
A	FD2G.K=SMOOTH(SF2G.K,DEF4)	13.34

A	Y03.K=SMOOTH(SF3.K,DEF6)	13.35
A	FD4.K=SMOOTH(SF4.K,DEF7)	13.36
	INITIAL CONDITIONS AND PARAMETERS	
N	FD1G=FD1GI	13.50
N	FD1C=FD1CI	13.51
N	FD2G=FD2GI	13.52
N	FD2C=FD2CI	13.53
N	FD3=FD3Y	13.54
N	FD4=FD4I	13.55
C	FD1GI=4OE6	13.56
C	FD1CI=4OE6	13.57
C	FD2GI=1OE7	13.58
C	FD2CI=1OE7	13.59
C	FD3I=24E6	13.60
C	FD4I=685E3	13.61
C	DEF2=1	13.62
C	DEF3=1	13.63
C	DEF4=1	13.64
C	DEF5=1	13.65
C	DEF6=1	13.66
C	DEF7=1	13.67
C	STDV2=0	13.68
C	STDV3=0	13.69
C	STDV4=0	13.70
C	STDV5=0	13.71
C	STDV6=0	13.72
C	STDV7=0	13.73
C	CBY=0.92	13.74
C	CC17=0.0252	13.75
C	CC18=0.1770	13.76
C	FPAX=3.92	13.77
C	FU1G=C.81	13.78
C	FU1C=C.81	13.79
C	FU2G=C.81	13.80
C	FU2C=C.81	13.81

APPENDIX XIV

FIG. 14 ASIF EXPENSE FORECASTING MODEL

FIG.14 ASIF EXPENSE FORECASTING MODEL		
NOTE		
A	F1E.K=E71C+E715+E722+FHE1.K	14.01
42A	FFH1.K=FCC.K/((S423)(C424))	14.02
A	FHE1.K=(FFH1.K)(E716+E728+E723+0)	14.03
42A	FFH2.K=FPC.K/((S418)(C417))	14.04
A	FHE2.K=(FFH2.K)(E816+E828+E823+0)	14.05
A	F2E.K=E810+E815+E822+FHE2.K	14.06
42A	FFH3.K=FD3.K/((SPD3)(CAP3))	14.07
A	FHE3.K=(FFH3.K)(E916+E928+E923+0)	14.08
A	F3E.K=E910+E915+E922+FHE3.K	14.09
42A	FFH4.K=FD4.K/((SPD4)(CAP4))	14.10
A	FHE4.K=(FFH4.K)(E715+E728+E723+0)	14.11
A	F4E.K=E710+E715+E722+FHE4.K	14.12
A	FFTE.K=F1E.K+F2E.K+F3E.K+F4E.K	14.13
A	FTE.K=FFTE.K#NORMRN(MEAN,STDV1)	14.14
A	SF1E.K=SMOOTH(FTE.K,DEF1)	14.15
A	TEX.K=(SFTE.K)(PCT3)	14.16
44A	F1EA.K=(ADE.K)(FMC1.K)/FIC.K	14.17
44A	F2EA.K=(ADE.K)(FMC2.K)/FIC.K	14.18
44A	F3EA.K=(ADE.K)(FMC3.K)/FIC.K	14.19
44A	F1ET.K=(TEX.K)(FMC1.K)/FMC.K	14.20
44A	F2ET.K=(TEX.K)(FMC2.K)/FMC.K	14.21
7A	FMC.K=FMC1.K+FMC2.K	14.22
44A	F1ED.K=(DTE.K)(FCC.K)/FML.K	14.23
44A	F2ED.K=(DTE.K)(FPC.K)/FML.K	14.24
44A	F3ED.K=(DTE.K)(FDC34.K)/FML.K	14.25
7A	FML.K=FCAP.K+FD34.K	14.26
9A	FT1E.K=FCER.K+F1EA.K+F1ET.K+F1ED.K	14.27
9A	FT2E.K=FPER.K+F2EA.K+F2ET.K+F2ED.K	14.28
7A	FT3E.K=F3EA.K+F3ED.K	14.29
A	DTE.K=(SFTE.K)(PCT4)	14.30
A	ADE.K=(SFTE.K)(PCT2)	14.31
INITIAL CONDITIONS AND PARAMETERS		
N	SFTE=SFTET	14.50
C	SFTEJ=4331.8E3	14.51

C DEF1=1
C PCT2=0.047
C PCT3=0.080
C PCT4=0.873
C STDV1=0
C MEAN=1.00

14.52
14.53
14.54
14.55
14.56
14.57

APPENDIX XV

FIG. 15 TARIFF FORECASTING MODEL	
NOTE	
7A	TIM.K=XYZ.K-TIME.F.K
7A	FAE2.K=FT2E.K-ADJ2.K
48A	ADJ2.K=PD.K/(XYZ.K-TIME.K)
48A	ADJ1.K=CD.K/(XYZ.K-TIME.K)
A	SFE.K=FT1E.K+FT3E.K-ADJ1.K
A	STR.K=FD34.K/FML.K
13A	F3AE.K=(SFE.K)(1.15)(STR.K)
7A	FLAE.K=SFE.K-F3AE.K
A	FD2.K=(FD2G.K)(FU2G)+(FD2C.K)(FU2C)
A	FD1.K=(FD1G.K)(FU1G)+(FD1C.K)(FU1C)
A	TR1.K=FLAE.K/FD1.K
A	TR2.K=FAE2.K/FD2.K
20A	TR3.K=F3AE.K/FD34.K
7A	XYZ.K=XYZI+TIS.K
1CA	TIS.K=T11.K+T12.K+T13.K+T14.K+T15.K+T16.K
45A	T11.K=STEP(52,52)
45A	T12.K=STEP(52,104)
45A	T13.K=STEP(52,156)
45A	T14.K=STEP(52,208)
45A	T15.K=STEP(52,260)
45A	T16.K=STEP(52,312)
INITIAL CONDITIONS AND PARAMETERS	
6N	XYZ=XYZI
N	T11=T11I
N	T12=T12I
N	T13=T13I
N	T14=T14I
N	T15=T15I
N	T16=T16I
C	XYZI=104
C	T11I=C
C	T12I=C
C	T13I=C
C	T14I=C
15.01	
15.02	
15.03	
15.04	
15.06	
15.07	
15.09	
15.10	
15.11	
15.12	
15.13	
15.14	
15.15	
15.18	
15.19	
15.20	
15.21	
15.22	
15.23	
15.24	
15.25	
15.5C	
15.51	
15.52	
15.53	
15.54	
15.55	
15.56	
15.60	
15.61	
15.62	
15.63	
15.64	

C T151=0
C T161=0

15.65
15.66

APPENDIX XVI

SPECIFICATIONS, PRINT, PLOT -- INFORMATION

```

NOTE BASIC MODEL
PRINT 1) ISIG, SIGT, SDIG, SRIG, GIG, FDIG
PRINT 2) ISIC, SIC, SDIC, SRIC, GIC, FDIC
PRINT 3) ISG, SG, SDG, SRG, G, FDG
PRINT 4) IS2C, S2C, SD2C, SR2C, G2C, FD2C
PRINT 5) IS3, S3S, SD3, SR3, G3, FD3
PRINT 6) IS4, S4E, SD4, SR4, G4, FD4
PRINT 7) MR1, MP1, BR1, CR1, PD, CD
PRINT 8) MR2, MP2, BR2, CR2, ADJ1, ADJ2
PRINT 9) MR3, MP3, BR3, CR3, TE, TI
PRINT 10) MR4, MP4, BR4, CR4, CSH, PDA
PRINT 11) SMT, FTCB, FH1, FH2, FH3, FH4
PRINT 12) TCAP, S3S, S4E, TRN, PCA, CCA
PRINT 13) TC1, TC2, CB1, CB2, FIE, COR
PRINT 14) TR1, TRF1, TR2, TRF2, TR3, TRF3
PLOT D1G=G, D1C=C, SIG=1, SIC=2, SDIG=X, SD1C=Y/SRIG=3, SF1C=4/CB1=B/CCA=M
PLOT D2G=G, D2C=C, S2G=1, S2C=2, SD2G=X, SD2C=Y/SK2G=3, SR2C=4/CB2=B/MPR=M
PLOT D3S=S, SD3=N, S3S=3/D4E=E, S4E=4, SD4=X/FH1=A/FH2=B/FH3=C/FH4=D
PLOT ER1=1, BR1=A, CR1=X/ER2=2, BR2=9, CR2=Y/ER3=3, BR3=C, CR3=Z/CSH=$
PLOT TCAP=T/CCA=C, FCC=1/PCA=P, FPC=2/TRN=N, SMT=5/S4E=E/S3S=S, FD34=F
PLOT TR1=1, TR2=2, TR3=3, TRF1=A, TRF2=B, TRF3=C(0,0,0.20)/CD=K, PD=P/TE=E, TI=I
PLOT ER1C=1, SX1=A, FCER=F/ER2C=2, SX2=B, FPER=E/SXX=$/ER4=4, BR4=D, CR4=X
PLOT FD1G=C, FD1C=1/FD2G=P, FD2C=2, FCB2=F/FD34=3, FCB1=E/FFTE=$, SFTE=S
PLOT SFTE=$/ADJ1=1, ADJ2=2/FPER=Y, F12E=P/FTIE=C, F1AE=D/FT3E=S, F3AE=I/FCE
X R=X
SPEC DT=0.1/LENGTH=10/PRTPER=2/PLIPER=?

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